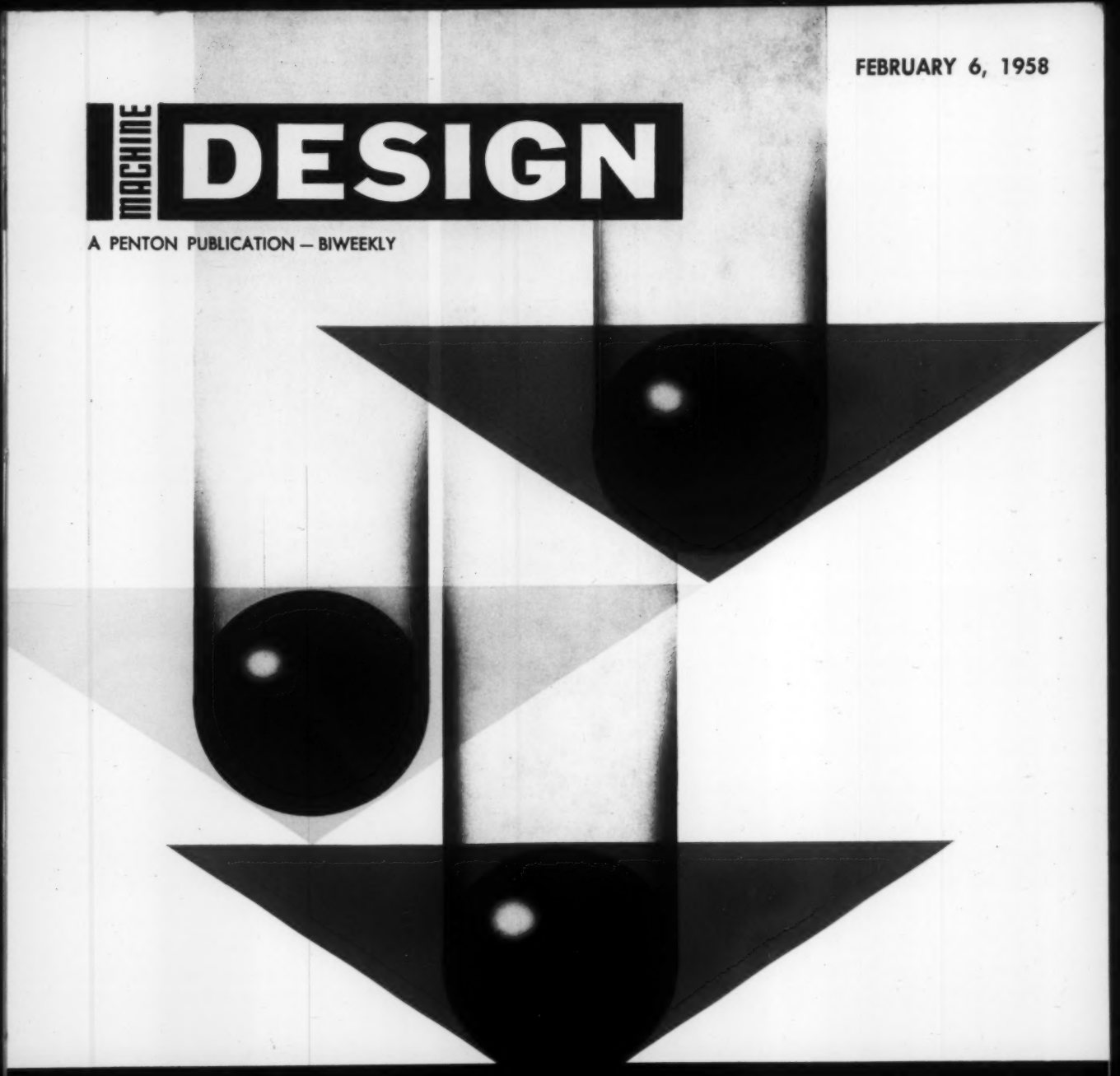
FEBRUARY 6, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Shot Peening

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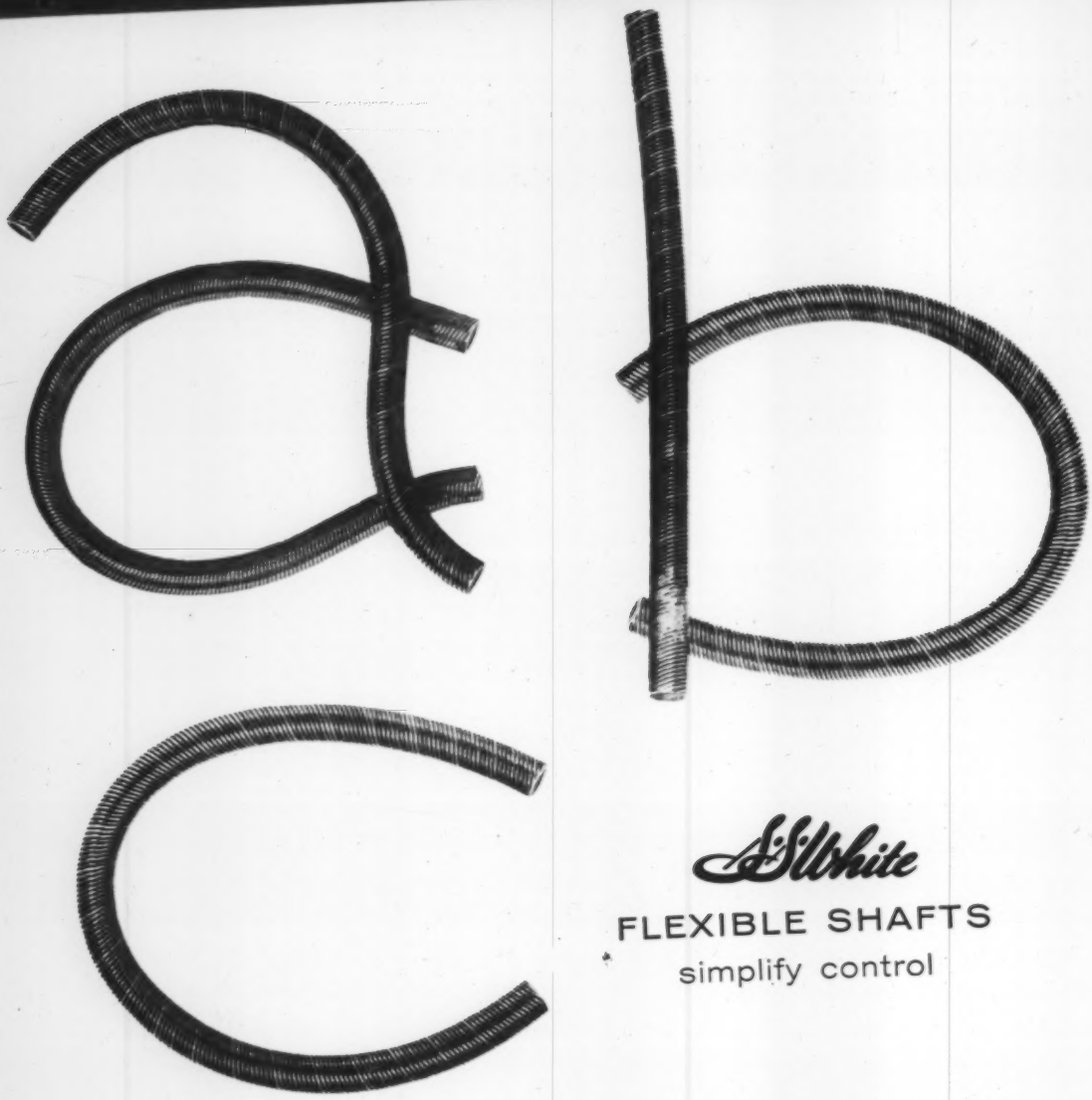


S. S. White

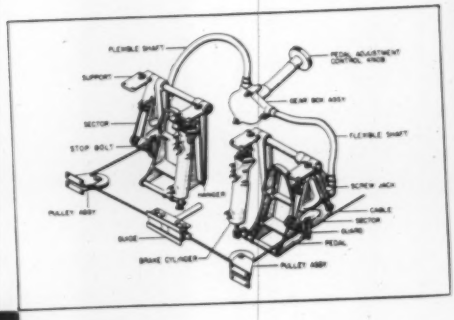
FLEXIBLE SHAFTS

simplify control

Here is a drawing that shows an adjusting mechanism that allows aircraft pilots to raise or lower rudder pedals to the most convenient operating position. The entire control system is S. S. WHITE-made: flexible shafts, handwheel, T-drive, and two adapters with extension shafts.

This is an example of the simplicity and adaptability of S. S. WHITE Flexible Shafts to hundreds of successful control applications. Designers find that with flexible shafts, power sources . . . driven members . . . controlled parts and their controls can be positioned better . . . with fewer parts and low assembly cost. Simplify with flexible shafts and save costs, weight, space, etc.

In your own product, S. S. WHITE Flexible Shafts may be the simple solution to your power-drive and remote-control problems. These quality shafts incorporate the latest engineering and technical advancements in both design and manufacture. For more information and expert assistance in selecting and applying S. S. WHITE Flexible Shafts to your product, just write to



S. S. White

FIRST NAME IN FLEXIBLE SHAFTS

USEFUL DATA on how to select and apply flexible shafts! Write for Bulletin 5601.

S. S. White Industrial Division, Dept. 4, 10 East 40th St., New York 16, N. Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

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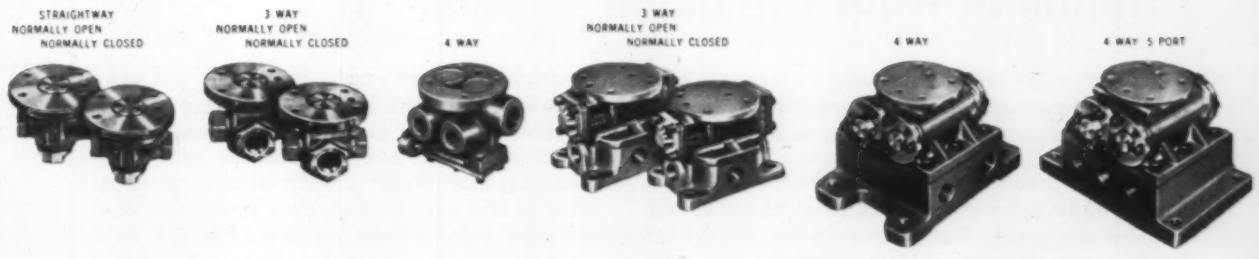
Ross Skyline

Now-All the basic valves-*and more*-in this *long life* air valve series

match any head to any valve body!


STRAIGHTWAY NORMALLY OPEN NORMALLY CLOSED
3 WAY NORMALLY OPEN NORMALLY CLOSED
4 WAY
3 WAY NORMALLY OPEN NORMALLY CLOSED
4 WAY
4 WAY 5 PORT

Now there are 11 heads and nine bodies to meet both usual and unique problems in the line which was designed to give you the longest life and greatest adaptability of any valve line in the world. All heads are readily interchangeable with all Skyline valve bodies, and the new Double-Stroke momentary adapter further multiplies the number of valve combinations. What is your problem? Drop us a note explaining it, or call your nearby Ross field service engineer for details on the Skyline valve to solve it.

Circle 404 on Page 19

Combining Engineering With Ingenuity for Better Air Control

Ross OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVENUE • DETROIT 3, MICHIGAN

Bonds beyond the usual bounds

Bonding rubber to metal was long a bugaboo to both manufacturers and users of many molded rubber parts. But today, at Goodyear, it's a problem of the past.

Originally, production methods of obtaining adhesion centered around a very limited group of metals and rubber compounds. But, over the years, the molded rubber specialists of Goodyear perfected new techniques of bonding which opened entirely new fields for the use of rubber by design engineers.

Unmatched rubber-to-metal bonding is just one of the advantages of working with Goodyear on molded or extruded rubber goods. Other reasons are outstanding product design assistance, rubber compounding, mold design and the latest in production methods and equipment plus the expert help of the G.T.M.—Goodyear Technical Man. For full details write to Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

MOLDED GOODS by

GOODYEAR

THE GREATEST NAME IN RUBBER

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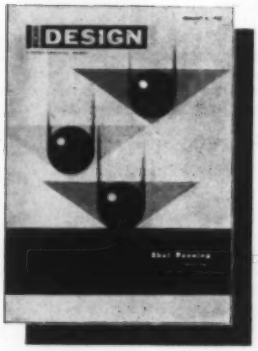

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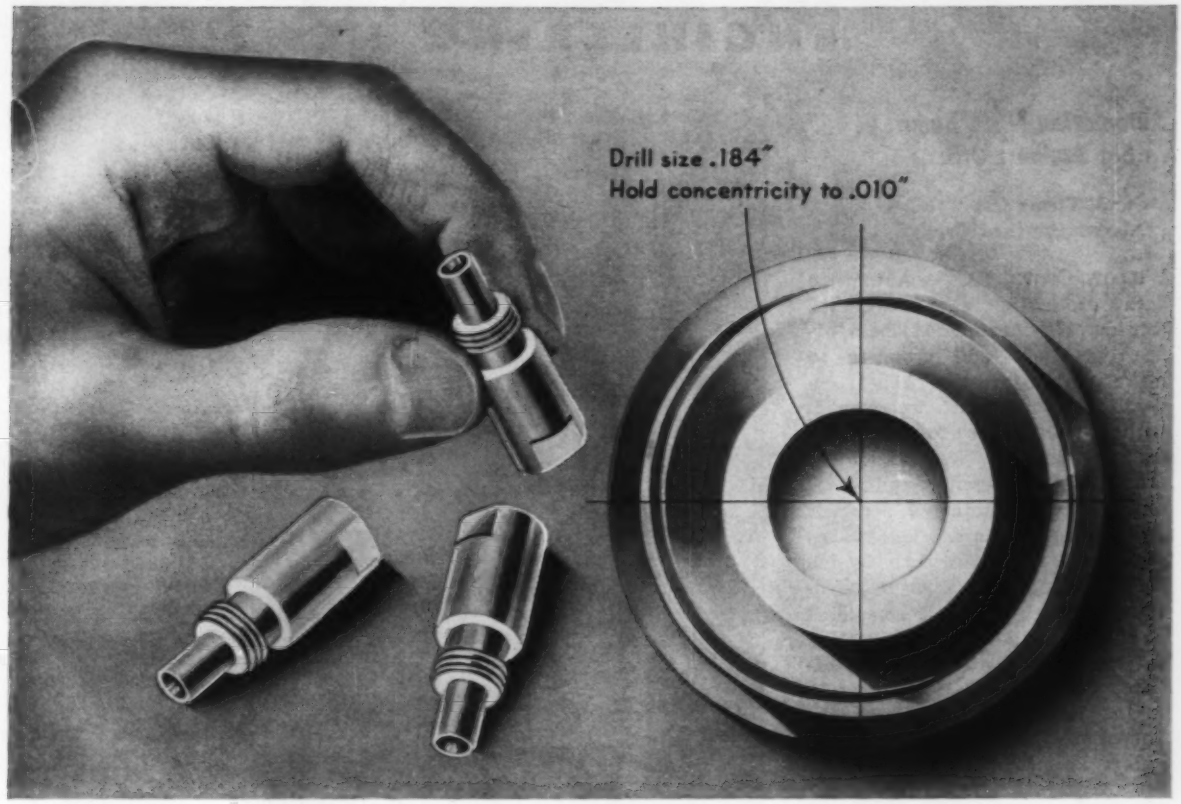
How Anaconda can help you get the exact Rod to fit the job



THE broad line of Anaconda free-cutting copper and copper-alloy rods gives you widest latitude in selecting from warehouse stock the precise rod for most screw machine jobs. But every once in a while there are special requirements.

One company's problem: The M. J. Grass Screw Machine Products Co., Buffalo, N. Y., machines a part for a gas-burner base from ½" round free-cutting brass rod. Specifications call for a hole $1\frac{1}{16}$" deep by .184" in diameter—with concentricity held to .010".

With standard free-cutting brass rod the drill had a tendency to wander, running the concentricity off as much as .024". To correct this, The American Brass Company provided rod stock with a minor variation in fabrication for deep drilling. This free-cutting brass rod has a slightly harder core, which minimizes the tendency of the drill to run off center at the high drilling speeds used. Now M. J. Grass holds the concentricity to .008" or under. With regular free-cutting brass, rejects ran as high as 15%. With the deep-drilling rod, there are no rejects.

Your requirements: Anaconda Rods are consistently uniform in composition, temper, and free-cutting characteristics. Consequently, they make possible easy duplication of cutting speeds and feeds known to be satisfactory from previous job records.

When you need special physical characteristics, such as a harder core for deep drilling or additional ductility to permit spinning or cold forming after machining, either the temper, the alloy, or both can be adjusted to meet your requirements.

Free technical service: It is the function of the Technical Department of The American Brass Company to assist metal users in the solution of special problems. This service is at your disposal without charge.

Comprehensive data on composition and machinability of standard Anaconda Alloys, standard specifications, weights, and dimensions of standard rods is available in Publication B-3. For this booklet – for special technical assistance – write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 3770

ANACONDA® RODS FOR SCREW MACHINE PRODUCTS

MADE BY THE AMERICAN BRASS COMPANY

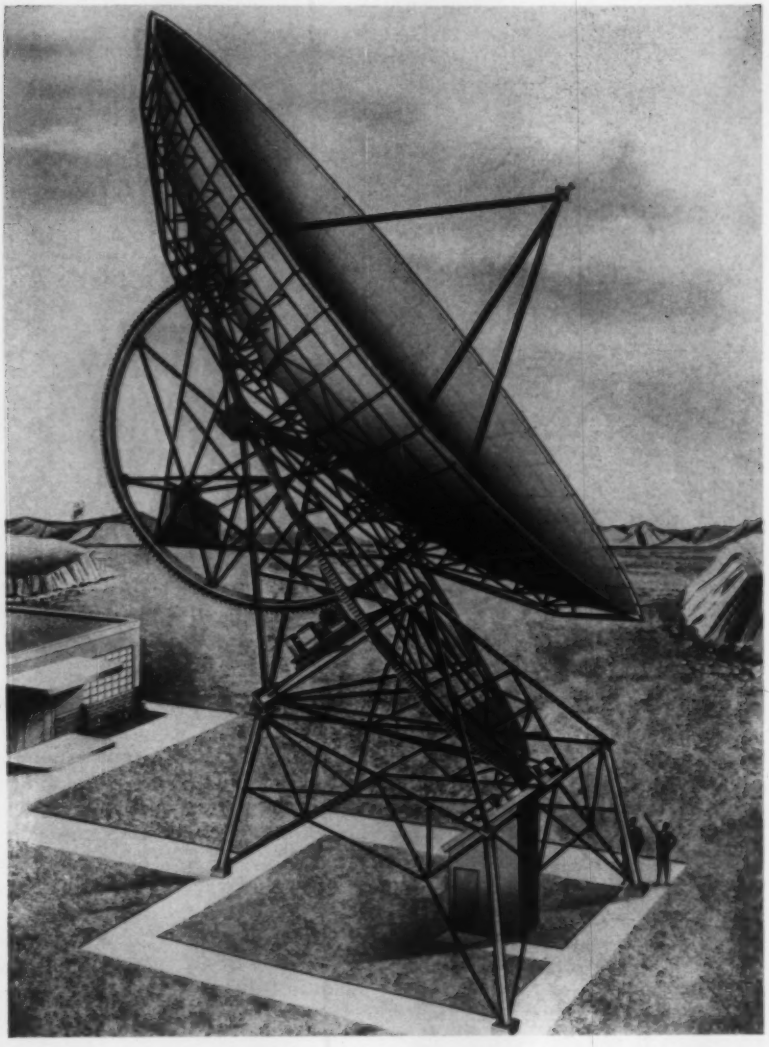
Automation Finds Home In Big Business Offices

Small Firms Use Too, Accent Punched Cards

WILLOW GROVE, PA. — Automatic data processing equipment has considerably modified business office operations and promises to make further inroads. Repeat orders for equipment are strong, with greatest needs shown by firms using punched-card systems, 45 per cent of whom have more equipment on order with another 7 per cent considering reorders. These findings were reported recently by the National Office Management Association, which has just completed a study of the current use and future needs of automation in offices.

One interesting aspect of the survey is that the use of office automation is shown to increase distinctly with size of the office. Contact with offices having more than 5000 employees shows that 100 per cent use punched card systems; 50 per cent also use electronic data processing equipment costing over $50,000. Of offices with groups of less than 26, only 5 per cent have punched card systems and none report the use of electronic data processing.

Although most forms of data processing may be used for a number of different jobs, the most popular applications are punched card systems for sales statistics, mechanical systems for order-invoice operations, and electronic systems for payroll work and engineering computations.



MORE DATA IN PROBING THE UNIVERSE are expected with the erection of a highly sensitive, 85-ft diam radio telescope near the University of Michigan. The parabolic, sky scanning instrument will be the largest of its kind in the U. S. Now being designed and built by the Tower and Antenna Dept. of Blaw-Knox Co., the telescope is scheduled to be operational by early summer, in ample time to collect data for "summary findings" of the International Geophysical Year. For extreme weather conditions, the telescope will be gear-driven to a stowed position in order to "ride out" possible hurricane velocity winds. The face of the instrument will be so sensitive that the reflecting surface may be adjusted to $\pm$ ¼ in. of a true parabola. The reflecting dish will be driven to compensate for the earth's rotation; will follow travel of the stars.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN→

...Fluid Power news

NEW 2,000 psi LONG-LIFE STEEL CYLINDERS

New Oilgear "Quality-Line" 2,000 psi Cylinders—for your tough jobs

Double-Acting Cylinders Designed for Continuous, Dependable, Long-Life Service

✓ Check these "Quality-Line" Cylinder Features:

✓ Dependable, Leak-Free, Long-Life Service Assured
Oilgear Cylinders still operating efficiently after 20 or more years in heavy-duty steel mill operations, presses, machine tools—cause equipment builders and users alike to claim—"For the lowest cost per year—it's Oilgear!" This reputation for reliability is the result of craftsmanship in every phase of proven, "gimmick-free" design and production that only four decades of experience can produce.

✓ Two Ram Sizes Available For Each Cylinder Bore Size
Standard or large—ground and polished rams have threaded ends and multiple wrench flats. Large rams provide exceptional rigidity and high return speeds.
Optional: alloy or hardened steel rams; chrome plating; special ram ends.

✓ Rugged, Shock-Resisting, "Hot-Rolled," Bar Steel Heads
Accurately machined and gauged for concentricity with cylinder bore and ram. New design saves space. Extra-large machined passages and pipe-tap-ports reduce fluid velocities, turbulence, and pressure loss. Straight or special tapped ports available.

✓ Confined, Preloaded, Super-"O" Cylinder Seals
Insure permanently leak-free, static and pressure seals between cylinders and heads.

✓ Heavy-walled, Seamless Steel Cylinders Precision Bored, Honed, and Polished
Carefully gauged for roundness, straightness, size—minimizes friction, slip, and wear.

✓ Simplified, Rotatable Head Mountings
Split, alloy-steel keeper rings and steel flanges allow heads to be rotated to any degree for mounting . . . re-positioned, or removed for inspection independently.

✓ Short, Recessed, Steel Tie Bolts
Eliminate long, sagging tie bolts, axial compression load on cylinders, distortion, stretching, exposed threads and nuts . . . permit individual head removal.

✓ Pistons Accurately Machined Concentric With Ram

✓ Four Precision-Fitted, Automotive-type Piston Rings
Effective sealing, exceptionally long life under severe, high temperature service.

✓ Molded, "V"-Type, Preloaded Ram Packing
Positive sealing action with uniform low friction characteristics. Face-mounted gland prevents excessive tightening and binding on ram.

✓ Large Area, Bushing Bronze Ram Guide

✓ Molded, Non-abrasive, Unit-Seal Ram Wiper
Has low friction coefficient—effectively removes dirt or abrasive material to prevent scoring ram, packing and guide wear, or infiltration into system. Maintains a sharp edge to uniformly clean the ram on every cycle.

✓ Exclusive, Self-Aligning, Adjustable Hydraulic Cushions
Available in front, rear, or both heads to eliminate shock, piston scoring, rapid wear, and check valves . . . an exclusive Oilgear design.

✓ Custom Application-Engineering Service
Given specific information, Oilgear Application-Engineers can recommend the best cylinder for your application. Oilgear will also custom-design and produce cylinders and complete Fluid Power Systems to exactly match your Controlled Motion requirements.

Call your local factory-trained, Oilgear Application-Engineer. Or write, giving specific information directly to

THE OILGEAR COMPANY
Application-Engineered Fluid Power Systems
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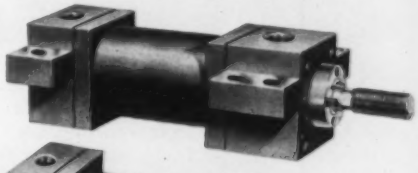
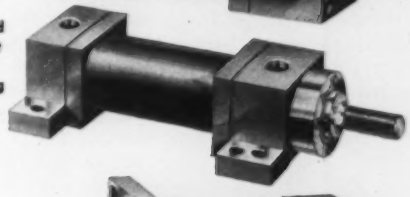
STANDARD MOUNTINGS

Heads can be combined, interchanged—rotated or removed independently.

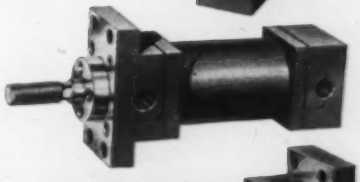
Front and rear Center Lug Mounting



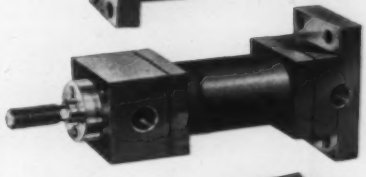
Front and rear Foot Lug Mounting



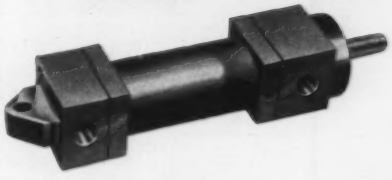
Front Flange Head Mounting



Rear Flange Head Mounting



Clevis Mounting and Plain Front Head



SIZES

Bore Diameter (i.d.)		2"	2½"	3¼"	4"	5"	6"	7"	8"
Standard Ram	Ram Diam.	1"	1"	1¼"	1½"	2"	2½"	2¾"	3"
	Max. Stroke	55"	60"	60"	65"	85"	95"	105"	110"
Large Ram	Ram Diam.	1½"	1¾"	2¼"	2¾"	3½"	4¼"	5"	5½"
	Max. Stroke	80"	87"	95"	105"	125"	140"	155"	160"

Longer Stroke Cylinders Available On Request

4 Oilgear Cylinder Bulletins Available On Request

No. 71000—2,000 psi Standard Cylinders

No. 73000—3,500 psi Heavy-Duty Cylinders Lug and Flange Mounted

No. 73245—3,500 psi Heavy-Duty Cylinders Hollow-Trunnion Mounted

No. 79000—Heavy-Duty, Custom-Built Cylinders

IT'S IMPOSSIBLE to produce reprints on the spot in Polaroid cameras. This was told to Waldemar A. Ayres, who is credited with 165 patents and was formerly director of research with White Sewing Machine Co., and before that, planning assistant to the vice president for engineering research at Sperry Gyroscope Co. The result—reprints on the spot. Ayres' process uses a lightproof entrance on the side of the camera through which he inserts the initial print in front of unexposed film. Light passing through the lens continues through the translucent print to make the reprint.

DRIVERLESS DIGGER permits operator to stand at a safe distance and perform perilous or inclement operations by remote control. Atomic waste removal and digging in arctic regions are two proposed uses. Built by Sherman Products Inc., the new digger can excavate a trench 15 ft long from one tractor position. Arc of swing is 188 deg, reach below grade, 12 ft, and loading height, 9 ft. The machine is said to exhibit outstanding speed and power characteristics including a breakaway capacity of 9000 lb. Tapered shovel sides prevent binding, and the shovel itself can be quickly and easily adjusted for hole digging or trench excavation.

Color fidelity of a complete TV broadcast system can be evaluated by a quality-control monitor, recently announced by the Broadcasting and TV Equipment Dept. of RCA. The unit provides precision checks of color registration, color balance, shading, deflection and transmission system transients, effects of pedestal adjustments, as well as camera deflection linearity, chroma level, and phase or hue adjustments.

Its features include feedback stabilization throughout, kinescope protection from loss of horizontal deflection or video overdrive, and regulated voltages for stability.

Topics

Flat spare tire is one of the latest ideas for future automobiles. The new spare is a rubber-rimmed steel saucer wheel that mounts over the deflated rubber tire. Such a spare takes up less space in the shrinking trunks of modern automobiles. Firestone's Perma Spare, first to be introduced, has a 2-in. rubber rim, weighs 30 lb.

• • •

Quickly pickled are cucumbers treated by a new electrical process. A 15,000-v shot of electricity through the pickles reduces curing time from two months to five days.

• • •

First cousins of the lead balloon, concrete-winged flying tow targets are being used by the French. Smoothly polished concrete wings withstand higher temperatures than metal ones, will not lose shape or strength, and are flexible because of the imbedded steel cables which are used for reinforcement.

• • •

Sweet nothings: An ear-plug radio receiver tuned to a modified dictating machine gives a Westinghouse worker step-by-step instructions in wiring a complicated board for an industrial control panel. This procedure has doubled productivity, cut rejects considerably, and eliminated the two-month training period formerly required for the job.

• • •

Next week (Feb. 9-15) is National Electrical Week; Feb. 11 is Thomas A. Edison Day.

• • •

Aging in ice improves aviation gasoline, according to observations of the Army Corps of Engineers. Gasoline stored for seven months in pits in the Arctic Icecap was lower in moisture content than when it was placed there.

• • •

First Science Explorers post in Boy Scoutdom has been chartered at Newport Beach, Calif., sponsored by Helipot Div. of Beckman Instruments Inc. The first Explorer unit to be devoted exclusively to scientific pursuits, it comprises 28 members of high-school age whose projects range from construction of a small-scale cyclotron to solid state diffusion research. Scout officials believe the program will stimulate interest in science and engineering as careers.

Circle 407 on Page 19→

BOUND BROOK'S BIG PLUS IS SERVICE

"NEWS ITEM No. 2—1958"

Bound Brook is the only powder metallurgy bearing and part manufacturer that has field offices staffed with experts to serve you . . . . . *Meet the Key men in the new field organization . . . . . .*

Henry J. Caul, district sales manager in the Northeast area. 37 years with Bound Brook.

James H. Hodgkins, district sales manager in the Chicago area. 16 years with Bound Brook.

J. J. Scott, district sales manager in the Detroit area. 21 years with Bound Brook.

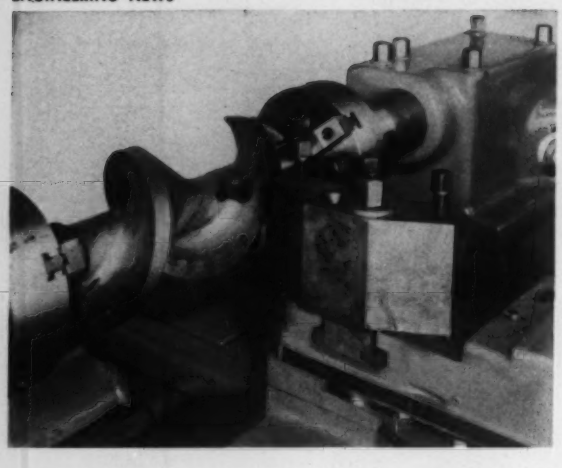
BOUND BROOK

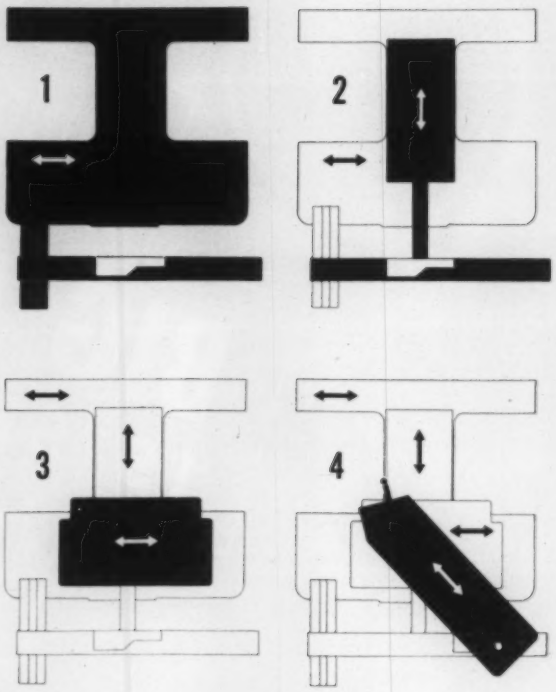
BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

our 75TH year





In contour-chasing lathe: 1. Carriage provides length motion for tool. Template carrier moves lengthwise with carriage. 2. Cross slide gives cross travel plus automatic tool relief. 3. Length slide provides feed. 4. Template-controlled tracer positions tool for each successive cut to produce contour.

Contour-Chasing Lathe Machines Spiral Parts

Inexpensive Templates Map Sharp Rotor Contours

CINCINNATI—Design freedom and inexpensive masters are two clear advantages of a newly designed contour chasing lathe. First application for the modified, 32-in., standard-duty engine lathe, developed by the R. K. LeBlond Machine Tool Co., was to machine concave and convex contours on a spiral-shaped part.

Previously, shapers had been used to generate the spiral surfaces, but this "straight line" machining limited the design of the rotor contours. Outstanding feature of the new machine is the unique application of a tracer unit. Instead of continuously tracing, it traces for a segment of each cut and positions the tool for each successive cut. Tool cutting motion is accomplished by "chasing" the spiral; the same as chasing threads.

The carriage, synchronized with the spindle, chases spirals. Mounted on the carriage is the usual cross slide, which automatically provides in and out tool motion for tool relief. On the cross slide, a special-length slide, tracer unit, and template automatically position the tool between cuts. Each feeding of the length slide moves the tracer stylus slightly along the curved template, which positions the tool for the next cut. The template carrier is mounted on the carriage and moves with it, instead of being fixed to the bed. Automatic cycling built into the machine permits completely automatic operation after setup.

Someone Say Shortage?

Openings for professional engineers as filed with the public employment offices for the month of November, 1957, were 2006, compared with 6472 requests for the same period of 1956. This includes 608 requests for electrical engineers, 573 for mechanical (excluding aeronautical), 290 for civil, 168 for aeronautical, 118 for industrial, and 56 for metallurgical. October, 1957, openings were 2888 as compared with 6491 for the same month of 1956. Latest data complied by Bureau of Employment Security covering the period Jan. 1-15 includes 593 requests for electrical engineers, 551 for mechanical, 347 for civil, 123 for industrial, 52 for metallurgical and mining.

Army Plans for '62: Portable, Powerful Forces

WASHINGTON—Future warfare will stress the independent action of small, highly mobile, widely dispersed battle groups operating under—or under the threat of—nuclear weapons. Based on these precepts, principal Army staff members recently disclosed some long range organizational policies, to be effective by 1962.

The smaller battle groups will be armed with extremely powerful but highly complex weapons. Since basic simplification of these future weapons is impossible, personnel officers have concluded that recruits with rudimentary aptitudes and low intelligence would be useless, if not dangerous, in the 1962 Army.

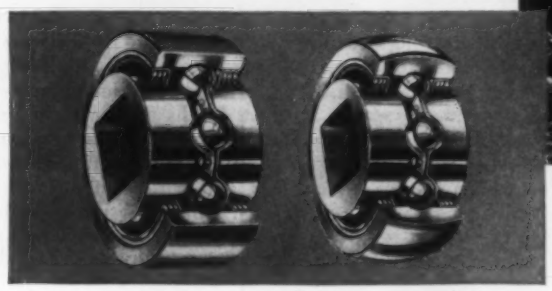
Army logisticians are confident that by 1962, troop requirements for the three basic essentials—ammunition, food, and gasoline—will be cut to a minimum. Fast, airborne delivery of all supplies should be possible. Very small yield atomics will replace the heavy tonnage of conventional ammunition. Irradiated and dehydrated foods will provide the familiar Army nutritional diet. All heavy engines should be compression-ignition types which have diesel economy

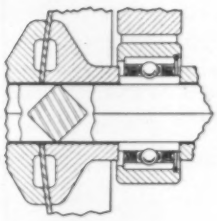
ND FACTS

DIRT SEALED OUT
GREASE SEALED IN

With New Departure heavy duty disc bearings, the performance proved triple lip seals keep lubricant *in* bearings—dirt, dust and wear sealed *out.*

Here is new bearing dependability . . . virtually service-free operation . . . for disc harrow buyers. Bearings are available with cylindrical or spherical outer rings, and square or round bores—outstanding examples of bearings engineered by New Departure to simplify mounting design and cut machinery costs. Remember, too, experienced New Departure sales engineers are always at your service.



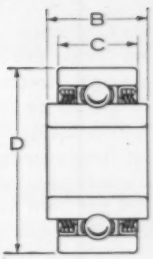


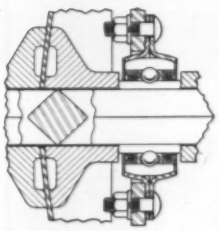
TYPE II

DIMENSIONS — TYPE II — CYLINDRICAL O.D.

Bearing No.	Shaft Size II		O.D. +.000 −.001	Ring Widths ±.005	
Sealed	Nominal	Max.	D	Inner B	Outer C
AS4508AD	1" Square	1.035	3.150	1.688	1.312
AS4508BD	1⅛" Square	1.120	3.150	1.688	1.312
AS4509AD	1¼" Square	1.285	3.346	1.688	1.312
AS4511AD	1½" Square	1.536	4.000	1.750	1.438
AS4508ED	1½" Round	1.535	3.150	1.688	1.312

For easy, simple mounting in cast housings. Square or round bore. Prelubricated and sealed for life.



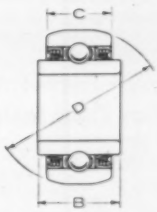


TYPE III

DIMENSIONS — TYPE III — SPHERICAL O.D.

Bearing No.	Shaft Size III		Spherical O.D. ±.005	Width ±.005	
Sealed	Nominal	Max.	D	Inner B	Outer C
AS4508FC	⅞" Square	.905	3.438	1.688	1.312
AS4508AC	1" Square	1.035	3.438	1.688	1.312
AS4508BC	1⅛" Square	1.120	3.438	1.688	1.312
AS4511AC	1½" Square	1.536	4.125	1.750	1.438
AS4508DC	1⅛" Round	1.192	3.438	1.688	1.312
AS4509BC	1¾" Round	1.780	3.438	1.688	1.312

Spherical outer ring for alignability in flange mounting, square or round bore, prelubricated and sealed for life.



1908–1958
GM
FORWARD FROM FIFTY

Send for complete details on Heavy-Duty Disc Bearings

ND NEW DEPARTURE
DIVISION OF GENERAL MOTORS, BRISTOL, CONN.
NOTHING ROLLS LIKE A BALL

Circle 408 on Page 19

and permit use of a wide range of fuels.

Current pentomic (small, highly mobile) divisions were fully reorganized this winter, six months ahead of schedule, and are designed to meet the requirements of a 1962 battlefield. The Army will continue to have infantry, armored, and airborne divisions. However, by 1962 there will be significant improvements in the capabilities of these divisions as new weapons and equipment—rockets, missiles, and electronics — are fully developed and integrated.

Engineering Enrollments Hit All-Time Peak

WASHINGTON — Total engineering enrollment in U. S. colleges is at its highest level in history with 297,000 engineering students registered, a recent survey shows. This represents an increase of 7.2 per cent over last year as compared with a more limited increase of 4.1 per cent for all college enrollments.

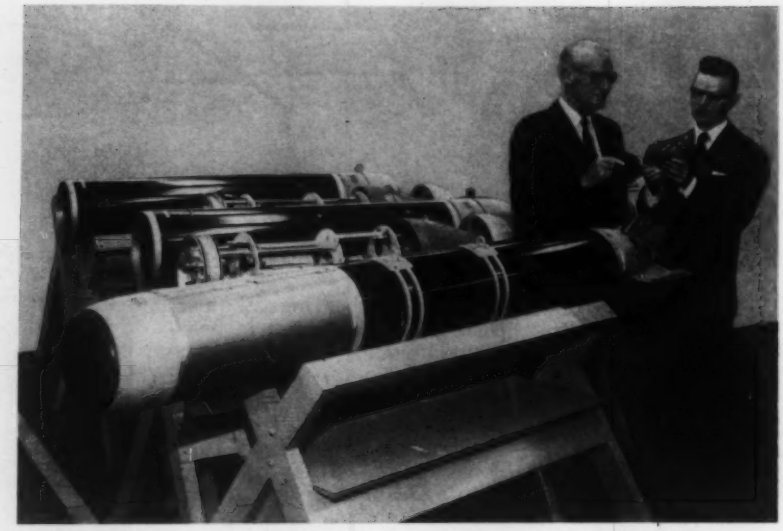
In the ninth annual survey of engineering enrollments conducted by the U. S. Office of Education, engineering freshmen enrollment was found to be 78,757, the second highest in history. Also, the number of engineering bachelors degrees awarded in 1956-57 increased by 18.6 per cent over the previous year, while the number of masters rose 10.8 per cent. The number of doctorates, however, declined by 2.3 per cent.

Tough Enamel Absorbs Stray Light Inside Camera

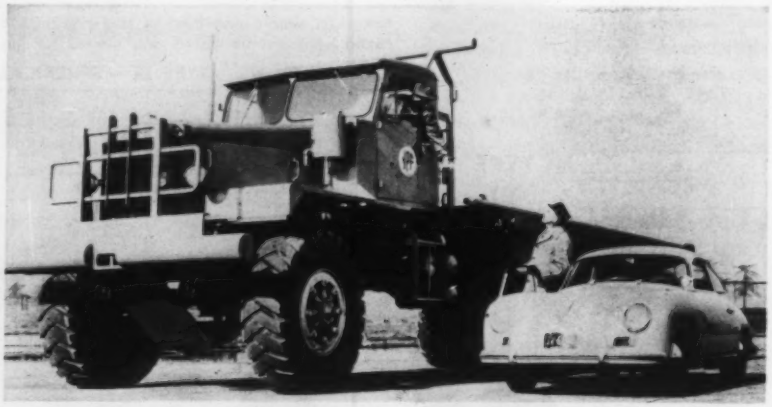
ROCHESTER, N. Y.—A nonreflective enamel, based on epoxy resins, is now used to coat the phenolic interiors of cameras. This replaces the use of an air-dry lacquer for which the phenolic surfaces were first sandblasted in order to assure adhesion.

The epoxy coating, Rexclad-R, is marketed by Rexton Finishes Inc., and is used on Eastman Kodak's Signet-40 cameras. It provides a black, nonreflective finish which absorbs virtually all stray light rays. Such rays, if reflected toward the film would result in flare spots.

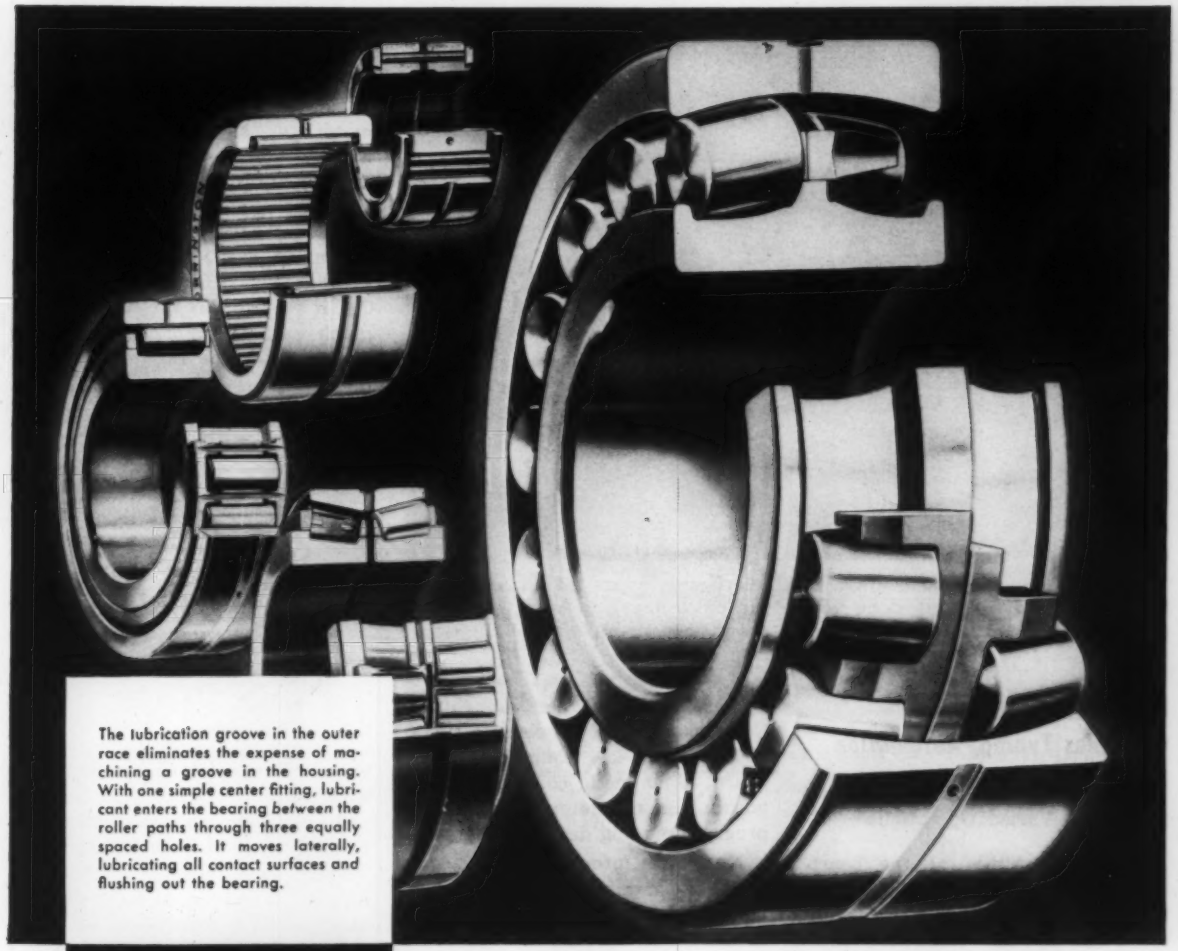
Like other epoxy coatings, Rexclad-R produces a hard, chipproof surface with single spray application, but it adheres permanently to molded phenolic surfaces. The coating material is a two-component system based on an Epon resin and suitable hardening agents.



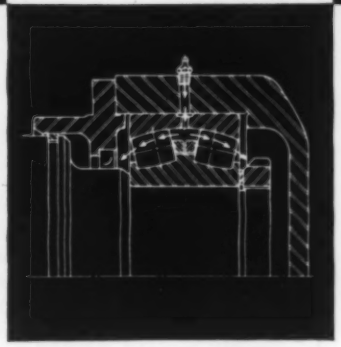
UNDERWATER GUIDED MISSILE, the Mark 43 antisubmarine torpedo weighs one-eighth as much as aerial torpedoes during World War II; can be launched either from aircraft or surface vessels. Approximately 8 ft long and 10 in. in diam, the Mark 43 is now operational equipment with all U. S. antisubmarine warfare fleets. Developed and manufactured by Clevite Corp., the torpedo can search to great depths for enemy targets. It homes in on its target by transmitting sound signals through the water and listening for an echo. Another newly announced acoustic torpedo, developed by joint effort of the General Electric Co. and Philco Corp., is the Mark 32. It can be launched from surface ships only. Also operational, the Mark 32 does not have to be fired from a torpedo tube, but is merely tossed over the side of a ship from an open launcher.



TEXAS-SIZE PICKUP TRUCK will be used for off-highway hauling of oil field equipment. Powered by a 300-hp diesel engine, the big flat bed model is 40 ft long, 11.5 ft high, and 11.5 ft wide. It weighs more than 32 tons; has an extra heavy body-frame structure to support various accessory equipment, including a 50-ton capacity Braden winch. It was built by Mack Truck Co. in a limited production run of five trucks.



The lubrication groove in the outer race eliminates the expense of machining a groove in the housing. With one simple center fitting, lubricant enters the bearing *between* the roller paths through three equally spaced holes. It moves laterally, lubricating all contact surfaces and flushing out the bearing.



A time-proved lubricating method now available on Torrington Spherical Roller Bearings

The circumferential groove in the outer race has met the test of experience in many Torrington Bearings, including Heavy Duty Needle Bearings, Aircraft Type Needle Bearings, Tapered and Radial Roller Bearings. Now the circumferential lubrication groove is available in Torrington Spherical Roller Bearings.

This design feature makes it possible to introduce lubricant *between* the roller paths without the expense of machining a groove in the housing. This groove is proportioned to provide generous lubricant flow capacity. Lubricant moves through the roller paths, flushing used lubricant and contaminants away from bearing contact surfaces.

Torrington Spherical Roller Bearings in many sizes may be ordered with this groove as desired at no additional cost. For further information, see your Torrington representative or write: **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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In electronic typing calculator, a small keyboard inserts all numerical information. Computing is done within the electronic gate, left. The relay gate, right, transmits instructions from program tape, and the electric typewriter automatically prints out the results.

Order-Invoice Computer Combines Typing, Automation

Magnetic Core Memory Enables Varied Operations

NEW YORK—Aimed at the heart of the accounts-receivable operation in thousands of businesses, an electronic typing calculator prepares invoices and orders and performs a variety of odd jobs. The new computer, which embodies magnetic core "memory," can be programmed to retain and type out total gross sales, taxes, shipping charges, invoice totals, or other accumulations for daily review.

The calculator, produced by the International Business Machines Corp., consists of an electric typewriter, a ten-key companion keyboard, a magnetic core "memory" within the computer unit, and a program reading device.

Numerical information, keyed in on the companion keyboard, can be added, subtracted, multiplied, rounded off, and held in "memory" for later processing; thus, the computer can automatically type, extend, carry totals, compute taxes, subtract discounts, position decimals, justify multidigit numbers, and type out results. Instructions for a complete procedure are provided by a plastic tape within the program reading device.

Sold to
MR. GEORGE ENRIGHT
ENRIGHT MANUFACTURING CO.
MARTINSVILLE, IOWA

Ship to
ENRIGHT MANUFACTURING CO.
MARTINSVILLE, IOWA

DATE	INVOICE NUMBER	CUSTOMER NUMBER	SALESMAN	SHIP VIA
1/6/57	78964	7602	DOE	PARCEL POST

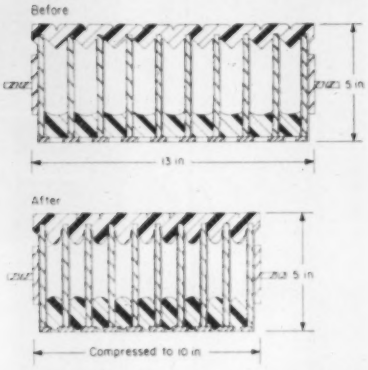
QUANTITY	PRODUCT NO	DESCRIPTION	UNIT PRICE	AMOUNT	TOTAL
110	6543	RELAY, DUO	5.25	577.50	
12	986523	RELAY, WIRE	2.50	30.00	

GROSS	DISCOUNT	TAX %	TAX AMT.	SHIPPING	INVOICE TOTAL
607.50	60.75	3	16.40	11.50	574.65

Calculator-prepared invoice show three types of information processing. Plain figures were typed manually on electric typewriter, figures in dashed-line boxes were inserted by operator of 10-key companion keyboard, and figures shown in solid boxes were automatically calculated.

Expansion Joint Flattens Roads, Aircraft Runways

AKRON—The periodic road shock motorists encounter on many highways will be eliminated and smoother aircraft landings will be made possible by the application of a recently developed rubber expansion joint. According to the B. F. Goodrich Industrial Products Co., it permits for the first time as much as 3 in. of contraction and expansion in the highway or runway while keeping the rubber flush with the surface.



A series of metal plates are bonded to the rubber to carry the vertical loads imposed on the joint by traffic. Anchored between road sections for a water-tight seal, the joint is about 13 in. wide. It extends the width of the highway or runway, and fully fills the joint connection to the depth required.

Make Tissue-Thin Strips Of Foam Rubber

OSSINING, N. Y.—Foam rubber in precision thicknesses is the culmination of a long search to answer requirements of hearing-aid manufacturing. At the research laboratories of Otarion Listener Corp., a new process makes strips of foam rubber 1 in. wide by 24 in. long in thicknesses down to 0.025 $\pm$0.003 in.

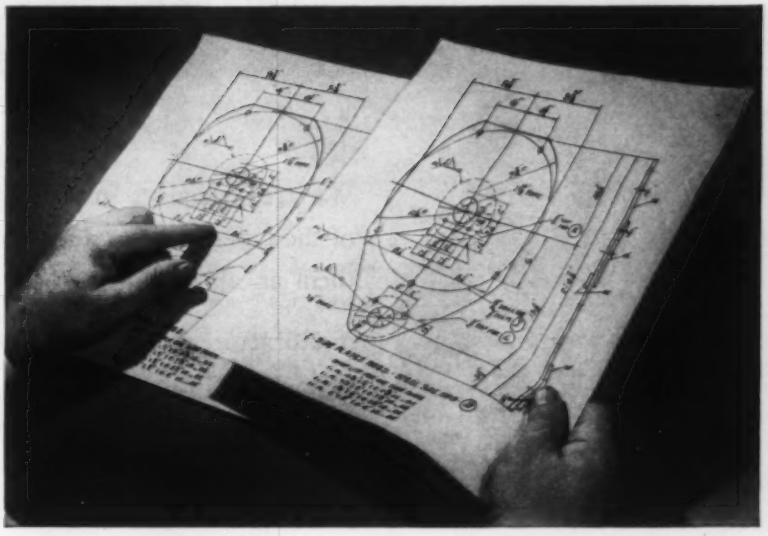
This is claimed to be the first time ultrasheer or tissue-thin strips of foam rubber have been produced. Production has now been extended to such grades of foam rubber as oil-resistant, reinforced, firm, medium, and soft—with open or closed cells. Preliminary studies indicate thin strips will find use

for acoustic and supension purposes, as gaskets, and in a variety of subminiaturized products.

MULTIPLEXER COMMUTATES signals from up to 90 transducers at 112.5 samples per sec and converts them into duration-modulated pulses suitable for telemetering or magnetic-tape recording. Developed by Consolidated Electrodynamics Corp., the device commutates and codes by interrupting light beam passage to photomultiplier tube.

Computation of upper air winds to aid weather reporting will be facilitated by a radiotheodolite purchased by the Government of Canada from Servo Corp. of America. The instrument will be used to indicate and record elevation and azimuth angle data. The radiosonde transmitter will telemeter temperature, humidity, and pressure measurements of the air through which the radiosonde passes.

DRAFTING TRENDS



Even a printmaking expert cannot look at these two prints and tell which original drawing was made on Phantom Ruled Blutex. Still, there were hours of difference in drafting time required to make the two identical drawings from which these prints came. Write today for a free sample of Phantom Ruled Blutex and see the proof for yourself.

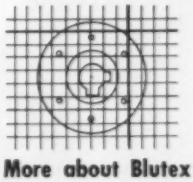
Phantom ruled vellum leaves more time for creative drafting

Working with scaling aids often takes valuable time from the basic job of creative drafting. Add the wasted hours spent drawing guide lines, lettering and handling similar routine drafting problems, and you have the reasons why POST developed Phantom Ruled Blutex.

This new vellum is basically POST's Blutex, unchanged except for the addition of phantom grid lines. The result is a combination of all the time-saving advantages of grid paper with all the drawing and reproduction advantages of famous Blutex vellum.

By using the grid lines, a draftsman works quickly to scale without constantly reaching for scaling instruments. Proportioning and resizing are easier and faster. Freehand drawing truly becomes a rapid, highly creative method of recording ideas. Even lettering and dimensioning are transformed into simpler, less time-killing jobs.

In printmaking, the grid lines disappear completely, leaving a sharp, contrasty print.



More about Blutex

The carefully controlled, uniform tooth on Blutex's surface easily "takes" dense, opaque pencil lines that resist smudging and smearing. Those sharp lines, plus Blutex's excellent transparency, assure fast printback and sharp reproductions.

Due to its carefully selected 100% rag content base, Blutex stands up well under prolonged handling. Even when alterations are done years after an original drawing is completed, Blutex still retains its fine ghost-free erasing qualities and easy erasability.

Free sample offer

For a test sample, write to the Reader Service Division of Frederick Post Company, 3652 N. Avondale Ave., Chicago 18.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
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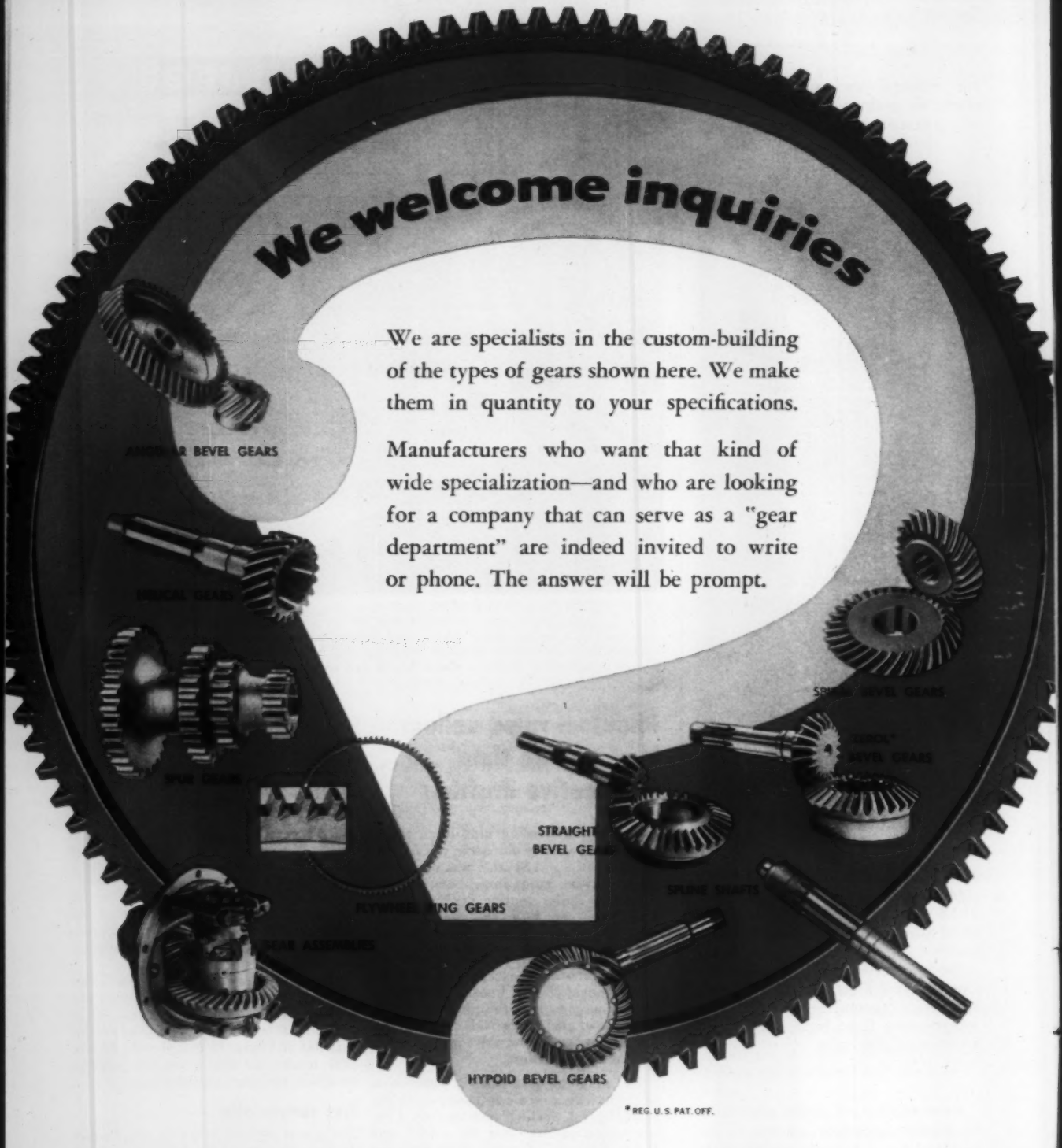
We welcome inquiries
We are specialists in the custom-building of the types of gears shown here. We make them in quantity to your specifications.
Manufacturers who want that kind of wide specialization—and who are looking for a company that can serve as a "gear department" are indeed invited to write or phone. The answer will be prompt.
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SPUR GEARS
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GEAR-MAKERS TO LEADING MANUFACTURERS

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Reader Information Service

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for More Information . . .

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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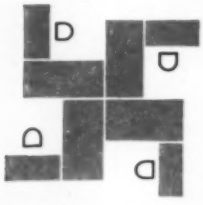

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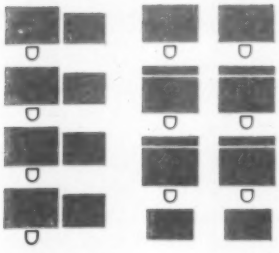

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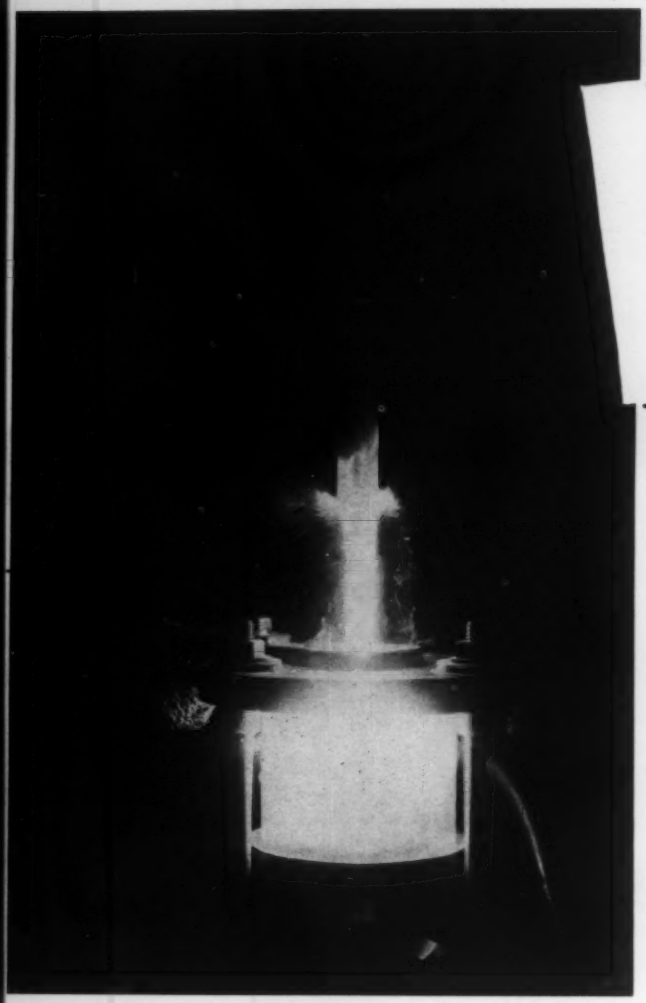


A roaring blast of gas and ionized water—at temperatures over twice those at the sun's surface—is one of the newest research tools for probing the thermodynamics of missile and rocket flight.

The Plasma Jet: Research at 25,000°F

By J. W. REID
Manager, Mechanical and Electrical Equipment
Aerodynamics Laboratory
General Electric Co.
Philadelphia, Pa.

BLAZING TEMPERATURES—over twice those at the sun's surface—are being produced today by plasma jets, a new tool for high-temperature research. Near-sonic-speed flows of plasma are maintained at 25,000 F with heat transfer rates over 1500 Btu per sq ft per sec for appreciable periods.

Problems in materials for missile re-entry have already been studied. Future possibilities range from ion propulsion drives for space ships to commercial application in metal cutting, welding, or plating.

Source of this high-temperature flow is the stabilized arc, an electric arc with its discharge stabilized by having it burn in the vortex formed by rotating water in a cylindrical swirl chamber. Temperatures as high as 90,000 F have been obtained in this type of arc.

High temperature of the arc causes rapid evaporation, dissociation, and ionization of the water. This gas, plus the products from the arc itself, is the plasma. Models are placed in this jet, which is so hot that most models last only a few seconds. Foreseeable developments in these arcs and the test tunnels used with them point to even higher temperatures and flows.

In a free-burning arc, temperatures of close to 12,000 F can be obtained. Temperature is increased in water-stabilized arcs by the decrease of cross section through which the current flows, and by cooling the outer layers of the arc, which forces most of the current to be carried near the arc center.

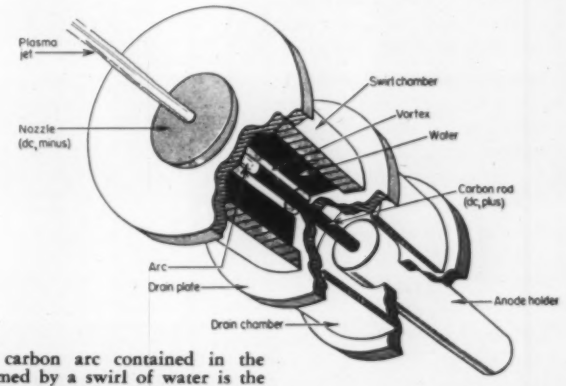
Swirl Chamber Design

A well designed and constructed swirl chamber is essential to the successful operation of any arc. In one proved design—being used successfully at Chicago Midway Laboratory—the chamber is a cylinder made in three sections: a center section of steel containing a tangential inlet for water, and two end sections of clear acrylic plastic (Lucite).

Heat radiated from the arc is so high that any dirt blemishes or cuts on the outside will absorb enough heat to start melting and

lead to failure. However, defects on the inner surface will not cause failure due to the fact that this surface is continually cooled by the circulating water. To overcome the problem, india ink is mixed with the swirl chamber water to absorb most of the radiated heat. Any O-ring which "looks" at the arc will also melt, so care must be taken to see that O-rings are also protected.

Another chamber design involves two concentric tubes of Lucite. Tangential water inlet is a slot, or series of holes in the inner chamber wall. Space between the two cylinders is kept filled with water. Over a thousand runs have been made with this design using tap water without replacements of major parts.



Stabilized carbon arc contained in the vortex formed by a swirl of water is the basis for the plasma jet. Water is evaporated, dissociated and ionized to form the plasma, which blasts out at near-sonic speeds.

Face of the chamber containing the cathode nozzle is also water cooled. In a vertical arc, a light, expendable sheet-metal plate with a hole in it for the jet is laid across the top of this end plate to protect the main plate from molten metal that drops from the model. Nozzles can be used for only one or two runs, so the design should allow for easy replacement.

One important design parameter is the ratio of inside diameter of the swirl chamber to the vortex diameter. A factor of 3 to 4 has been found satisfactory with larger ratios used for the smaller arcs. The inlet hole must be large enough for the required flow, and it must be drilled so that flow is tangential to the periphery of the chamber and at right angles to its axis.

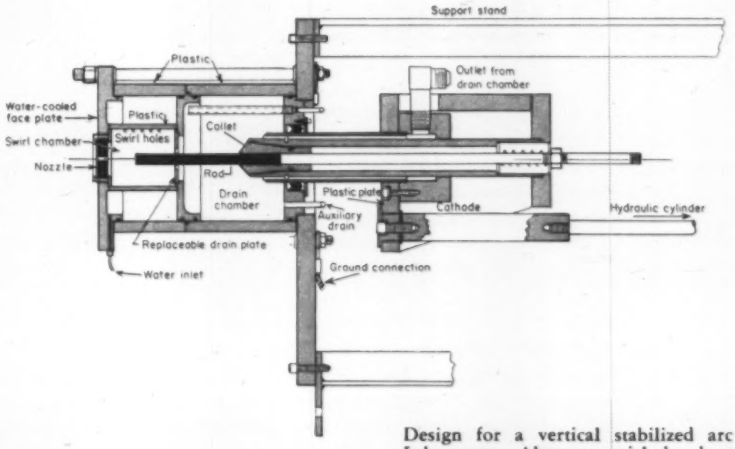
To maintain an even flow, a supply tank large enough to hold water for the entire run should be used. Water pressure should be held steady with an inert gas and regulating valve. A 30 to 80-gallon tank provides ample capacity for arcs up to 1 in. Tank pressures have ranged from 25 to 60 psi.

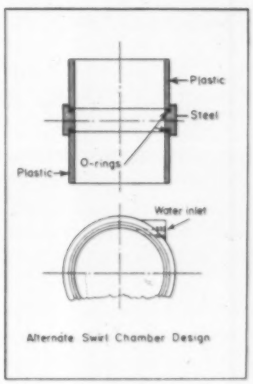
Vortex size is established by size of the hole in the drain chamber plate. The vortex must be larger than the nozzle diameter—even when the hole in the nozzle increases due to erosion and burning during the run. Drainage flow and vortex stability will be improved if the drain hole is given a generous chamfer or radius.

Misalignment of the rod will result in uneven burning and nonstable operation of the arc, while misalignment of the model will distort test results, so carbon rod, nozzle, and model must be carefully aligned. Care must also be taken to protect the sting supporting the model from heat of the blast.

Arc Control

Arc length must be constant during the run to maintain stable flow





Design for a vertical stabilized arc at G-E's Aerodynamics Laboratory. Alternate swirl chamber design is used at Chicago Midway Laboratories.

and reproducible test conditions. As the carbon rod is consumed, it must be continuously and evenly fed into the chamber to maintain the arc gap. An experienced operator can do this, but a hydraulic or mechanical drive controlled by either current or voltage variations is better. Also, with large arcs, the operator would need special protection from radiated heat.

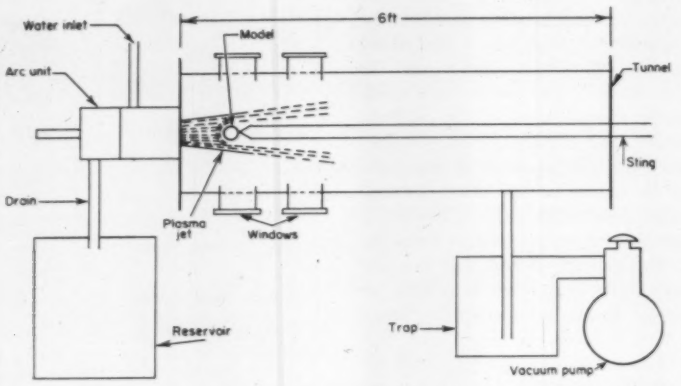
The arc can be started by advancing the rod until an arc is formed and then rapidly retracting it. Another method is to drill the end of the carbon rod and insert a smaller rod, which contacts the cathode. When voltage is applied, the small rod is consumed. A piece of wire can be used similarly.

Another method is to use an auxiliary "striker," a carbon rod that fits through the cathode nozzle and is attached to the same source of current as the nozzle. When the striker mechanism circuit is energized, it swings the auxiliary rod in line with the nozzle and moves the striker through the nozzle until the arc is formed. This surge of current actuates a retracting mechanism which rapidly withdraws the striker and swings it out of the way.

No matter what method is used to start the arc, the initial flow will not be stable. Since life of most materials in this hot plasma jet is measured in seconds, the sting and model-supporting mechanism should be designed so that the model is not placed in the jet until conditions are relatively stable. To provide reproducibility, the positioning device and stop should be designed for automatic operation so that the positioning cycle is completed without the need for human guidance. This is especially true for the larger arcs.

In the ½-in. vertical arc at G-E's Aerodynamics Laboratory at Philadelphia, a hydraulic feed mechanism is operated by hand or automatically controlled by voltage variation. The ½-in. carbon rod is held in a quick-opening collet to allow for small variations in rod size and to permit quick change.

Arc gap length is a function of the voltage drop. A rough approximation for this gap is 1 in. per 100 v drop; actual value depends on rod size, temperature, current flow, etc. Small arcs with ¼ to ¾ in. rod diam are generally operated on 150-400 v dc and at 20 to 75 kw.



Arc tunnel, used to obtain better flow of the plasma jet, is evacuated. Sting is located in the "shadow" of the arc, since life of most materials is very short in the arc blast.

A more stable arc results when there is enough resistance in series with the arc to absorb about half the voltage. In larger arcs (1 in. and above) it is advisable to provide two variable resistances, one in parallel and one in series, with the arc. This arrangement controls current flow through the arc, and the resistance in series also provides insurance against a dead short.

Test Tunnels

To obtain better flow, increase stability, and aid aerodynamics investigation, a tunnel has been designed into which the plasma jet is directed. By evacuating the tunnel, a more even flow can be obtained. This tunnel has been successfully operated with a ½-in. arc as the source of plasma.

Enough experience and information has been obtained to indicate that for larger sizes the tunnel will probably have to be water cooled. By injecting gas into the jet through the swirl chamber, or by using air as a stabilizing fluid instead of water, the flow through the nozzle into the tunnel can be increased and even better flows obtained.

Since hydrogen gas is one of the plasma-jet products, the tunnel must be properly vented. After a test, the model and sting will generally be hot enough to ignite any explosive mixture present.

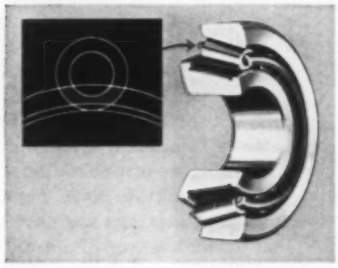
Eye protection will also be required to prevent "welding flash." With the large arcs, heat radiated from the model, jet, and arc will be dangerous. Sound levels from large arcs will also be high and must be considered in establishing arc location.

Do-It-Yourself Data

With the stabilized arc, high temperatures and flows can be obtained very economically, particularly when hand-operated small arcs are considered. Once the basic setup has been designed, the only additional equipment needed is a pressurized tank, dc generator sets (welding units can be used), standard resistances (for small arcs), and a few gages. Standard carbon rods can be obtained readily and can be machined into the cathode nozzle.

Possibilities for research and development are challenging. To mention only a few, the development of the arc and its equipment; the development of instrumentation; aerothermodynamics studies; basic research on gases, ions, and ion propulsion; atomic investigations; high-temperature furnaces; tunnels; and ignition sources.

Tomorrow's "dream" is our job today!



HIGHER FLANGE IMPROVES ROLLER ALIGNMENT

As shown by the gray area above, the higher flange provides a large two-zone contact area for the roller heads. This greatly reduces wear—practically eliminates "end play". Larger oil groove provides positive lubrication.

There's more to the car of tomorrow than just futuristic styling! Automotive engineers are working to perfect completely new power plants—like turbine engines—to achieve yet-unheard-of performance and economy! And they demand bearings that are as advanced as their thinking. This is no new challenge to Bower engineers. A glance at the design features listed at left will tell you a few of the many original Bower contributions to bearing performance which have reduced bearing maintenance and failure to a practical minimum. There are many more in the making. If your product is one which needs advanced bearings *today* plus realistic planning for the future, specify Bower. There's a complete line of tapered, straight and journal roller bearings for every field of transportation and industry.

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Plain and fancy, slow and fast,

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Small-Boat Fleet for '58

ALMOST ANY DEGREE of luxury, utility, and power that the boating public may want have been combined in expanded lines of small craft for 1958. Again this year, designers have met specifications of cost, speed and usefulness that seem to be substantially broader than corresponding specifications for automobiles. This year's fleet is marked by style changes, refinement of interiors, more powerful engines, better controls, and more complete instrumentation. Power, itself, has come to the point where one manufacturer cautions customers to use it sensibly.

Numbers as well as variety of boats have grown in recent years. The National Association of Boat and Engine Manufacturers counts 7,071,000 small craft in the U.S., powered by 756,000 inboard engines and 5,190,000 outboards.

At the top of the market that these figures represent are luxurious cruisers, custom made and stock types. More than other boats, these reflect automobile styling. Vertical fins introduced last year embellish more models in 1958, while in certain builders' lines they are notably absent. The Landau top, with slide-back roof section, has gained more favor. One line carries turn signals. Most have wrap-around windshields.

Chris-Craft, now a company of five boat-building divisions, offers eighty models for 1958, ranging from 17 to 35 ft in length. Its Boat Kit Division offers 16 models, the largest a 22-ft cruiser.

Ancarrow Marine introduces three new boats patterned generally on its *Aquilifer* of last year. The *Aquilifer,* itself, has been lengthened 1 ft. Two 300-hp inboard engines give it a guaranteed speed of 60 mph. Instruments include a tachometer, cylinder temperature gage, fuel-level gage, water speedometer, and depthometer.

Ten models comprise the Century Boat line, all made of fine woods. The line uses 17 different engines—a maximum choice of 9 on the elite *Coronado* 21 model.

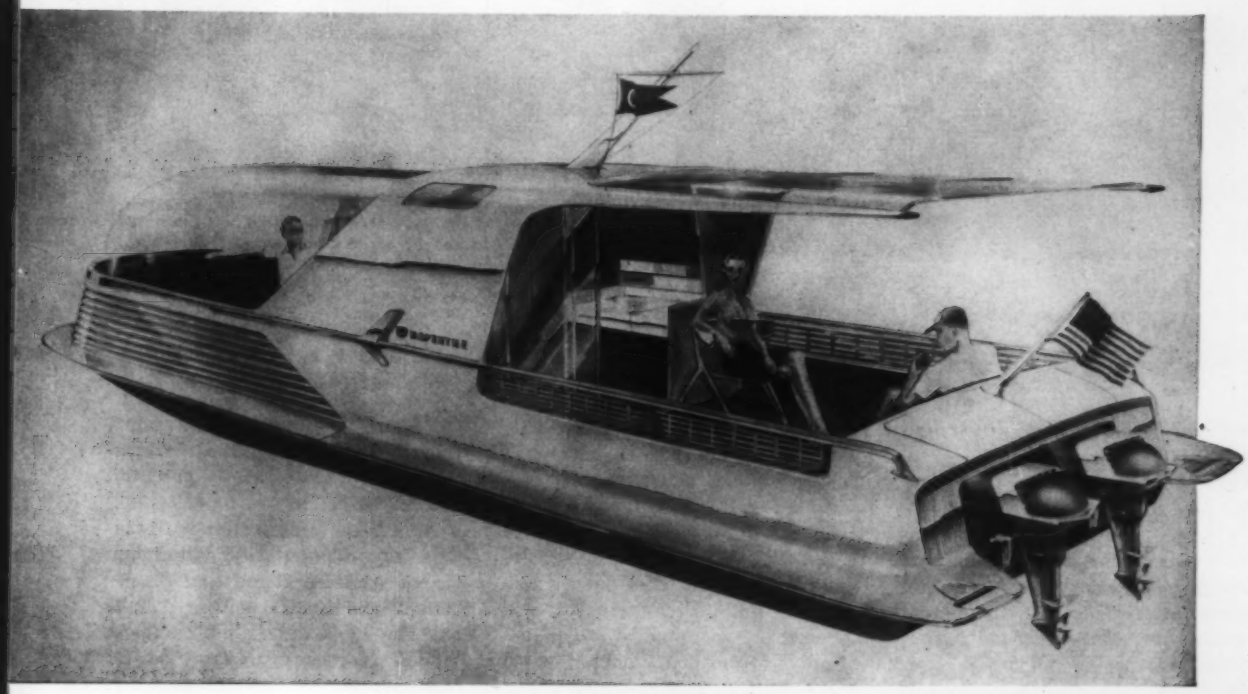
Carlisle Marine offers 5 models now, 2 more later. All are made of fine woods; all are 17 ft long. Engines of 65 to 109 hp give the *Aqua-King* model speeds of 32 to 43 mph.

Opposite to these cruisers in speed, but comparable in popularity, are commodious houseboats. The *River Queen* line consists of two models, 24 and 32 ft long. Hulls and decks are welded steel. Wood superstructures resemble house trailers; serve the same purpose. Inboard or outboard motors give speeds of 10 to 12 mph. Long trips are possible. *River Queens* are frequently "sailed" from Gary, Ind., via the Mississippi, to Florida.

Many families live in houseboats all year in seasonable climates. In the metropolitan New York area, houseboat marinas are part of several yacht basins. Children attend the nearest schools.

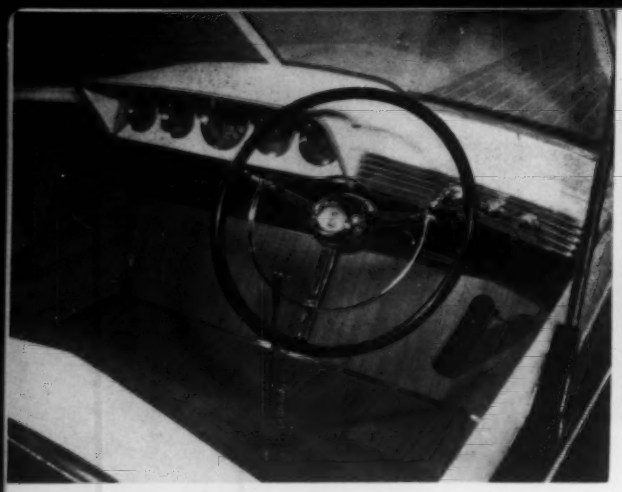
The ultimate in "sampan living," however, must be life aboard an American line of Chinese junks. Late last year a New Yorker formed the Transorient Boat Co. and announced he would import the bulky craft from Hong Kong. Made of teakwood, the junks would be 25 ft long, weigh 2 tons, sell for $4500 f.o.b. N. Y. The dealer cautioned that these figures

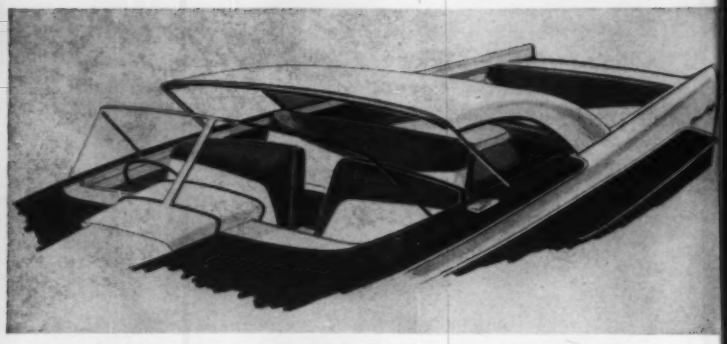
Aluminum "dream boat" conceived by Kaiser Aluminum & Chemical Corp. is actually an amphibian house trailer. Wheels retract into aluminum hull when the craft is "at sea."



High style, fine wood construction, and generous inboard power mark the new *Patrician* model by Ancarrow Marine Inc. It carries six on two seats upholstered with synthetic foam. A choice of six engines is available. The heaviest, model 225 Gray, gives *Patrician* a speed of 55 mph.

No fins, but a unique foredeck treatment distinguish this *Resorter* model by Century Boat Co. The boat is 19 ft long, 6 ft 10 in. wide, of fine wood construction. Power is from a choice of seven engines. The strongest, Cadillac Crusader V8-275, enables 46 mph. *Resorter* has a six-unit instrument panel, cigarette lighter, rear-view mirror, glove compartment, dash light, dash drawer.





Landau-style hard top, with slide-back forward canopy, is growing in buyer acceptance. This one is on the new Chris-Craft 21-ft *Continental*. Dashboard in the same model matches the highly styled exterior, shows distinctly the influence of automobile design.

are approximate "because Chinese boat builders would get bored if every boat order was the same and probably raise their prices."

Unusual configurations also include Grumman Boats' aluminum *Sea Wings* model, fitted with retractable hydrofoils, and a new version of the *Rocket Boat* by the Cheston L. Eshelman Co.

HULLS

Hull materials are wood, aluminum, plastic, and glass fiber. The most luxurious craft are still made of marine grades of fine woods—mahogany for outer surfaces—but the other materials are steadily displacing wood for smaller, high-production hulls intended to have outboard power.

Almost half of small hulls are still made of wood. To retain this market, builders have developed new techniques using molding plywood sheet. The Wagemaker Co. calls its own method Ply-Lap. Layers of cross-bonded veneer receive coats of phenolic glue onto which strakes—hull-length strips tapered in section—are applied. The assembly is bonded under 65 psi pressure and 275 F temperature. Finished hulls have smooth inner surfaces, lapstrake outer appearance.

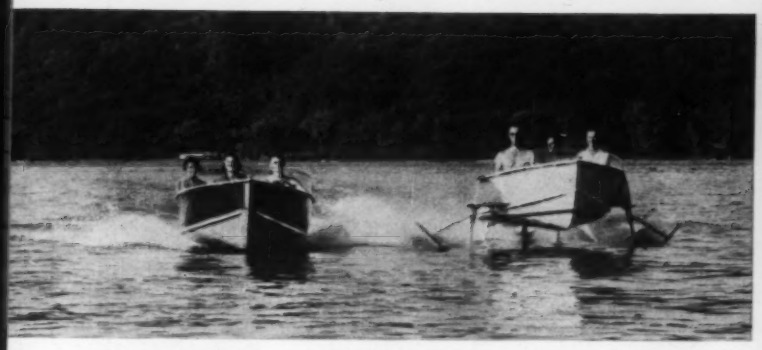
Penn Yan boats have plywood hulls made by the company's Dynamold process. A conventional boat skeleton is built up of bent oak ribs joined to lengthwise members. This frame takes all the shocks of boat operation. The hull skin is built up of four layers of molded marine plywood joined to the frame at a minimum of points, thereby minimizing the perforations for fasteners — potential sources of leaks.

Aluminum hulls are gradually increasing in popularity. Aluminum Co. of America found that 32 per cent of the 400,000 outboard hulls sold in 1956 were aluminum. A modest increase was expected for 1957.

There are two methods of shaping aluminum hulls. "Forming up" involves several precut, preformed pieces riveted or welded together to form desired contours. The second method is stretch forming. Sheets are die-formed in presses to hull shapes. Stretch forming is becoming the preferred method because it produces more pleasing contours and fewer visible seams.

Advantages of aluminum hulls

Strongest small boat for family use is claimed to be the Eshelman *Rocket Boat*, 14 ft long, 60 in. wide. Hull is formed of 16-gage cold-rolled steel. Planing bottom is reinforced plywood. Bumper rail outside the hull protects boat and passengers. Power is outboard, up to 60 hp. Novel bow suggests that *Rocket Boat* would be respected in heavy water traffic.



Hydrofoils on the stern and sides of the Grumman *Sea Wings* model make it 25 per cent faster than the counterpart 15½-ft *Deluxe Runabout* with the same power. Recommended engine is a 25 to 40-hp long-shafted outboard. Both boats have aluminum hulls. The hydrofoils can be raised and lowered easily; have shear pins in case of grounding. Made of plastic and glass fiber, they float if separated from the hull.

are durability, minimum calking, and light weight. Aluminum boats by Aero-Craft have Sta-Foils on hull bottoms. Ski-like hollow channels, open at the aft end, fill with water and improve hull stability when the boat is at rest. With the boat in motion, the Sta-Foils drain and function as planing surfaces.

About 22 per cent of outboard hulls are made of plastic and glass fiber. There are two manufacturing methods. The hand layup method involves laying glass fiber cloth in a female mold, then swabbing or spraying with adhesive resin. The process is repeated until the desired thickness is attained. The second method employs matched metal dies. Glass fiber mat is swabbed with resin and molded under heat and pressure.

Another method is announced this year by Rand Development Co. Activated resin and chopped glass fiber are sprayed into a mold by a gun-depositor until desired thicknesses are attained. The gun is used by one man, deposits 15 lb of material per minute, is claimed to save 40 per cent of the cost of laminating a 14-ft hull.

The largest glass fiber marine structure this year is the hull of the 40-ft (sailing) yawl *Vitesse*. Four have been built by Beetle Boat Co.

Acknowledged advantages of plastic and glass hulls include the absence of seams. They do not swell, shrink, or become waterlogged. Line and contours impossible with other methods can be formed in hull shapes. Disadvantages are that manufacturing defects may escape notice initially, the material takes less abuse than aluminum and, for the present, manufacturing cost is high.

POWER

V-type outboards are prominent innovations in power for boats this year. Both Johnson and Evinrude have introduced 90-degree V models (MACHINE DESIGN, November 28, 1957). Both have four cylinders, develop 50 hp, and have 70.7 cu in. piston displacement. Balanced crankshafts are appreciably shorter than in comparable conventional motors. Both motors use twin-barrel, downdraft carburetors.

A line of eight outboards from 2 to 35 hp is announced by West Bend Aluminum Co. The 2-hp model, unlike the others, is air cooled. Controls — gearshift, key starter, carburetor door, and choke—are clustered conveniently on one panel.

In the Mercury line for 1958 there are nine models from 6 to 70 hp. The latter is claimed the most powerful outboard in the industry. It is fitted with a choice of eight propellers from 7½ in. pitch three-blade to 21-in. pitch two-blade. The new Mercury model 28—22 hp—is claimed the first over 20 hp to have an automatic transmission. The entire motor is canted 15 degrees to the boat stern to help clear obstacles, and it exhausts underwater through the center of the propeller hub.

ACCESSORIES

With the increase in the number of boats, the number of boat trailers has increased correspondingly. Better performance on roads are claimed for new models. One by Sterling Boat Trailers has four tandem wheels for heavy loads and rough ground.

Other notable accessories are:

True-tracking radar and a radar off-center positioning device, by Sperry Gyroscope Co. (MACHINE DESIGN, August 8, 1957). Advantage is a relatively durable panoramic view of surroundings. Moving objects nearby show up with tails. Sperry is also introducing a 12-lb gyro-compass, thought to be smallest-of-type.

A lightweight anchor, originally designed for the Navy Seamaster seaplane, by Danforth Anchors. Holding power, based on design, is equal to a 500 lb kedge type or an 800 lb stockless type.

An aneroid barometer with a built-in alarm, called Storm Warner, by Hamlin Products Inc. The alarm sounds several minutes before sudden squalls to waken boaters at night or to take precautions any time.

Drinking glasses etched with authentic maps of the U. S. Coast and Geodetic Survey. They can be used for navigating, but if a boater were "in his cups"—these, particularly—he might be persuaded that the earth is neither flat nor spherical but cylindrical.

—S. R. GRIFFITH

Eddy Currents Heat German Cooking Unit

Magnetic Device Can Power Other Kitchen Appliances

CHICAGO—An experimental magnetic device uses eddy currents to cook foods. Known as a Magnetic Eddy-Current Cooking Device, the unit was recently sent over to this country from Germany and is under study by Tuttle & Kift, a supplier of electric heating elements for appliances.

The cooking device operates by rotating magnets relative to a stationary conductor, which in this case is the utensil. Electric currents induced into the utensil wall are converted to heat energy. As soon as the utensil is placed on the cooking surface, pan and food begin to heat. As soon as the pan is removed from the magnetic field, heat generation is stopped.

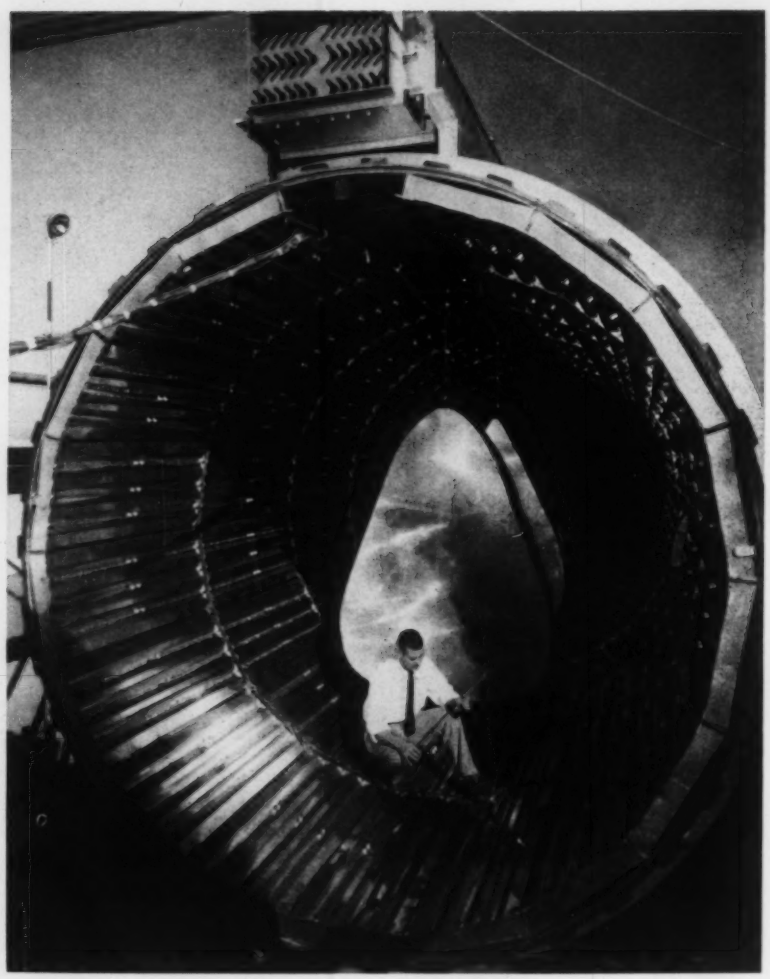
Heat is readily controlled by varying either the intensity of the magnetic field or its relation to the utensil. Mechanical control is accomplished by means of a knob which raises or lowers the unit in or out of the magnetic field.

A variety of small kitchen appliances may also be developed to exploit the eddy current principle. The unit has already been adapted to a blender, and may be extended to juicers, percolators, graters, and other kitchen aids.

Eddy currents save cooking time. In experimental eddy-current stove under study in Tuttle & Kift laboratories, a pint of water boils in approximately 100 sec; an omelet in 3 min, or approximately one-half the conventional cooking time.

Several advantages are claimed for this type of cooking:

1. Great savings in cooking time.
2. Much less heat in kitchen area. No stove heat to be removed.
3. Easier to keep clean. Spilled foods can be rinsed away; do not char the unit.
4. Increased safety. A paper napkin when placed between the surface of the device and a pan of boiling water does not burn.
5. Over-all dimensions of the magnetic unit are comparatively small. The prototype unit has three heating surfaces in a space of about 2 cu ft.



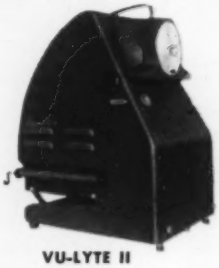
HIGH-SPEED HEAT and high-altitude pressures are simulated in this big vacuum test chamber at Convair's San Diego plant. Air conditioning and electronic systems for the F-106A all-weather interceptor are evaluated at Mach-3 temperatures— 830 F—and 100,000-ft altitudes. Entire fuselage of the plane is mounted in the chamber, surrounded by 750 infrared tubular quartz lamps. Filament temperature of each 2500-w lamp reaches 4000 F, and the entire system consumes 2000 kw of electric power when fully energized. Air is evacuated by steam ejectors and semibarometric condensers. Sea water is pumped in to condense the steam and thus pump air out.

Super-speed gears reach a pitch line velocity more than 420 mph—37,303 fps—in a gear box used for testing missile pumps. Gears' angular velocity is 67,000 rpm. Unit is rated at 600 hp; made by Western Gear Corp.

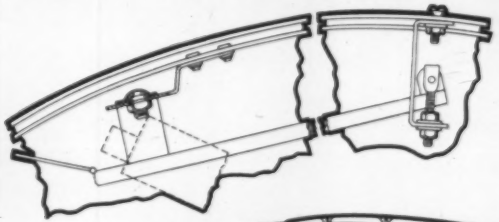
Waldes Truarc Rings cut assembly costs, improve performance of precision photo-optics equipment

Charles Beseler Co., E. Orange, N. J. uses Waldes Truarc Retaining Rings in 3 applications shown.

REFLECTING MIRROR ASSEMBLY IN OPAQUE PROJECTOR

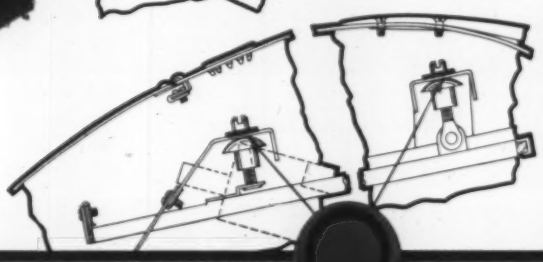


VU-LYTE II PROJECTOR



BEFORE

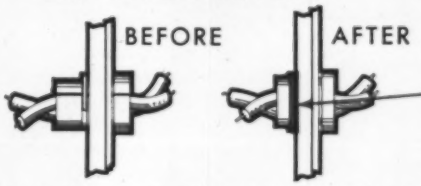
"The front surface mirror is the most precise optical element in a properly-functioning opaque projector," Beseler writes. "Previously we used this extremely cumbersome means of holding the mirror in position. As mirror adjustments are always required and the mirror is extremely delicate, our spoilage was terrific."



AFTER

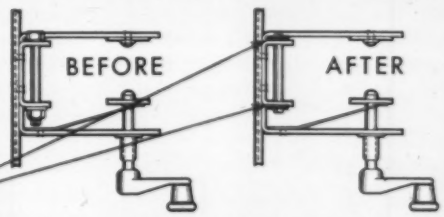
"Two Truarc Series 5100 Rings made possible complete redesign of the mirror assembly. Now mirrors can be adjusted from *outside* the projector. Rejects now are practically nil. More precise adjustment of the mirror is possible. And because of the greater ease in adjustment, we have cut labor costs $2.00 per unit."

HEAT ASSEMBLY IN PRINT DRIER



Here a Waldes Truarc crescent ring, Series 5103, replaced a split collar and clamping ring. Results: labor costs cut 50¢ per unit because of greater ease of assembly. Drier provides more uniform heating.

35 MM MICRO-FILM NEGATIVE CARRIER IN ENLARGER



2 Waldes Truarc Series 5133 E-Rings replaced 2 cap nuts—at a saving of 20¢ per unit in labor costs.

Whatever you make, there's a Waldes Truarc Ring designed to save you material, machining and labor costs, and to improve the functioning of your product.

In Truarc, you get

Complete Selection: 36 functionally different types. As many as 97 standard sizes within a ring type. 5 metal specifications and 14 different finishes. All types available quickly from leading OEM distributors in 90 stocking points throughout the U. S. and Canada.

Controlled Quality from engineering and raw materials through to the finished product. Every step in manufacture watched and checked in Waldes' own modern plant.

Field Engineering Service: More than 30 engineering-minded factory representatives and 700 field men are at your call.

Design and Engineering Service not only helps you select the proper type of ring for your purpose, but also helps you use it most efficiently. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

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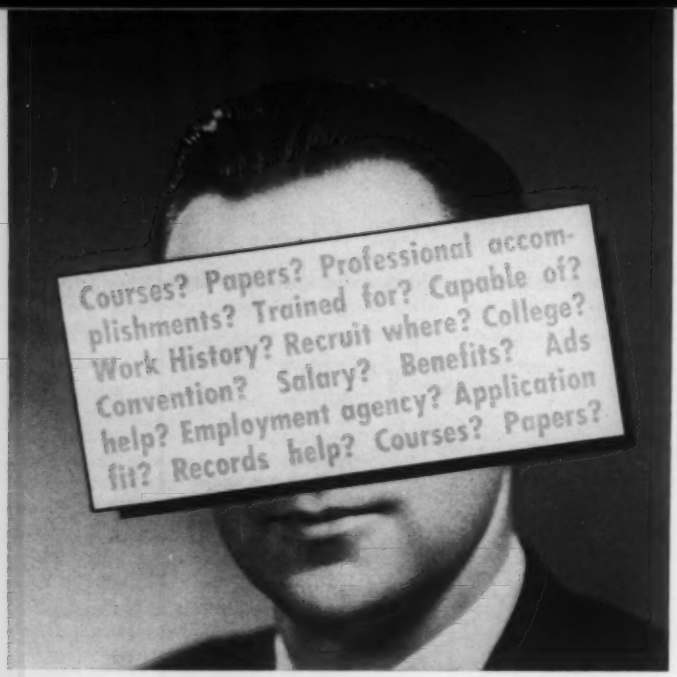

Courses? Papers? Professional accomplishments? Trained for? Capable of? Work History? Recruit where? College? Convention? Salary? Benefits? Ads help? Employment agency? Application fit? Records help? Courses? Papers?

HIRING:

THE GOVERNMENT'S large purchases of engineering services, both direct and indirect, have intensified competition for the available supply of engineers. Paced by companies which are involved in government cost-plus-fixed-fee contracts, the amounts of money expended by industry on advertising and recruiting have risen quite considerably over recent years.

Hiring engineers is an integral part of improving engineering productivity for two reasons: First, it sets the tone between employer and employee and exerts a strong effect on the engineer's motivation. Second, if performed carelessly, the wrong people are often hired. Much time can be lost trying to teach engineers tasks for which they do not have the necessary background, personality, or mental capacity.

According to the survey, *Engineering Manpower,* on which this series is based, five aspects of hiring merit serious consideration by engineering management: 1. Staff requirements. 2. Recruiting. 3. Recent graduates. 4. Application forms. 5. The role of advertising.

Staff requirements

In almost every company contacted, any decision to hire engineers is made by the chief engineer or a member of his staff. Management is generally forced to go along with the request of the engineering department or run the risk of not being able to meet commitments because of inadequate manpower.

When an unusual engineering problem arises, characteristic reaction of the chief engineer and management is to "Get someone in who can handle it!" Very seldom did anyone relate, as did one company executive, that by "carefully studying and fractionalizing sticky problems, we have almost eliminated our need for special skills."

One possible reason for this is that many companies with ample resources find it easier to hire out-

side engineers than to train people already employed. But when new people are constantly brought in from outside the firm to fill responsible jobs, morale of the engineers already employed invariably suffers.

Depending upon the company, the top engineering executive was found either to take charge of recruiting himself or else delegate it to the personnel department or to a member of the engineering staff.

Recruiting

Recruiting is big business. The survey assembled estimates from a variety of sources that indicate recruiting costs for some industries vary from a minimum of $1000 all the way up to $5000 for each man hired. Most of the larger companies maintain recruiting teams which travel about the country visiting colleges, conventions, and professional meetings.

The character of these teams is changing. Until recently, engineers were usually recruited from college and industry by representatives from the company personnel

office. Now, there is a growing trend to send engineers into the field to recruit engineers.

The "defense industries," notably the aircraft, missiles, and electronics industries, and to a lesser extent, the machine-tool and automobile industries, have set the pattern in salary plus fringe benefits. The result is that bonuses, fringe benefits, and other extras have become more important as bargaining weapons in the recruiting fields.

This situation poses a real problem to other companies. Once they have boosted salaries and increased fringe benefits, it is virtually impossible to reduce them. For the old-line companies, engineers and technicians are more of a long-term investment. For the defense companies, engineers and technicians are hired and kept only when there is contract work.

The growing emphasis on fringe

Facts and Implications . . .

benefits tends to downgrade the engineer. So much emphasis on extras, rather than on the nature of the work and the challenge it offers, tends to rob him of his professional stature. This overemphasis places him more and more, in the eyes of the layman, in the class of the skilled production worker who is typified by job "extras."

Intensive recruiting of experienced engineers seemingly takes place at conventions and professional meetings. Advertisements invite visits to hotel locations of company recruiting teams. Because the larger firms are more sophisticated in their approach and are able to afford hotel suites for recruiting purposes, representatives of the smaller companies often recruit on the floor of the convention hall. The recruiting phases of these shows and conventions are unofficial, but are reportedly the most active.

In the matter of recruiting, whenever an engineer shifts positions, considerable time for indoctrination is involved. This is true whenever anyone shifts positions, but the intensity of recruiting has served to multiply total nonproductive time. Thus strong intercompany rivalry for engineers is extremely wasteful of engineering manpower.

Recent graduates

It would seem that the greatest source of engineering manpower is the nation's colleges and universities. Recruiting is carried out here intensively also. However, the recruiting techniques employed are much more restrained. This can be attributed to the fact that placement officers generally exercise tight controls over which companies visit, what is said and done, and what offers and promises are made. Also there are fewer "deals," generally speaking, and more factual information is generally available to applicants at school placement offices.

It might be expected that there would therefore be less disillusionment once the graduate went to work. But dissatisfaction with professional employment conditions was found to be greater among recent graduates than among experienced engineers. Causes were difficult to determine. However, it may be that the younger men have more "blue sky" expectations.

Application forms

Among those contacted, few companies used special application or personal history forms for engineers. Special information was seldom desired about an engineer's courses, papers, and professional accomplishments. The answer was usually, "The forms are kept in the personnel office and they don't need that type of information anyway." Invariably the chief engineer or one of his immediate staff made the hiring decision. About 60 per cent of the time, the application form was available to the chief engineer for review. The rest of the time, it was not.

Checkpoints for Engineering Management

- ☑ **1. Does size of the engineering department fit company needs?**
- ☑ **2. When recruiting, does your company aim at long-range goals?**
- ☑ **3. Are your company policies well-considered with regard to fringe benefits?**
- ☑ **4. How effective are your application forms for engineers?**
- ☑ **5. Is your recruiting advertising directed, in fact, toward applicants?**

The hiring interview consisted almost always of simple verbal exchange between the engineering department representative and the engineer. In only 5 per cent of the companies questioned did the engineering department require the preparation of special personal history forms which remained in the engineering department files for reference and use. The other companies found no use for such data on engineers.

A recent survey on recruiting by Max A. Pape resulted in similar findings. Of 76 application blanks he examined, only seven were especially prepared for engineers. He concluded that 68 out of 75 application blanks were inadequate—the wrong questions were asked and not enough space was provided for education, work, history, and similar elements of background.

Findings on the number of companies using special forms for engineers appear significant. They are symptoms of a general attitude to the effect that the engineer is just another employee with no special abilities. Engineers and some executives with whom this question was discussed ventured the opinion that if more companies had a better idea what their technical people had been trained for and were capable of, there would be far less management preoccupation with getting new people all of the time.

The role of advertising

A Navy study compared the cost per new employee of 37 contractors with a preponderance of government business to a group of 17 contractors with mainly commercial business. Average recruiting cost for the commercial firms was $985 as compared with $1317, or $332 more per new employee, for the defense firms. The costs included expenditures for help-wanted advertising, recruiting, travel of applicants, moving of new employees, educational benefits, and other costs incident to hiring.

Advertising is a big item in recruiting costs. Yet the survey indicates that much of the advertising directed ostensibly toward reciting was in fact largely institutional in character.

It was found that only a given percentage of the younger men with experience shift positions, and the tremendous volume of advertising purchased is probably responsible for many of the shifts in this category. Advertising is not usually directed toward those engineers with more than five years experience, but without administrative background, who are considered a drug on the market. No one seems to want them because they no longer want to work on the bench, they want more money, and they have no proved administrative ability. Nor do those in the category of older engineers, with considerable administrative experience, shift positions as a result of advertisements. These men are more prone to obtain new positions through professional placement agencies.

Many corporation executives complain that high-caliber engineers don't generally respond to advertisements. Moreover, they frankly admitted that recruiting ads are one way to advertise the institution—especially since they are reimbursable under government cost-plus contracts.

Whatever the merits or demerits of the various types of advertising used, the survey replies indicate that the large amounts of advertising and intensive recruiting create a good deal of unrest among engineers in general. Motivation invariably is affected, even though indirectly.

Next article in this series will appear in the February 20th issue. It will deal with stockpiling of engineers, hoarding, and adequate technical staffing.

Recommendations for Management

1. Know Your Engineers

By means of supervisory and personnel channels, attempt to learn more of present engineer employees. Check current interests, previous training, and past accomplishments.

2. Study Manpower Needs

To ensure that only needed people are hired, pay close attention to the analysis of engineering needs. The importance of planning, work analysis, scheduling and budgeting has been discussed in a previous article. If improvements can be made in any or all of these areas, then clearly there will be a more realistic basis for determining manpower needs.

3. Investigate Applicants Thoroughly

Management is advised to take what may at first seem an unwarranted amount of time to study the prospective employee's application, to interview him at length, and to investigate obscure areas in his presentation. Moreover, it is essential to project the applicant's potential in the organization, insofar as his past efforts will indicate.

4. Oversee Graduates Closely

Although recruiting at college campuses is in general most closely monitored for ethical presentation, new-graduate employees are often disheartened when confronted with the actual job. For this reason, management will profit from careful observation and training of such employees.

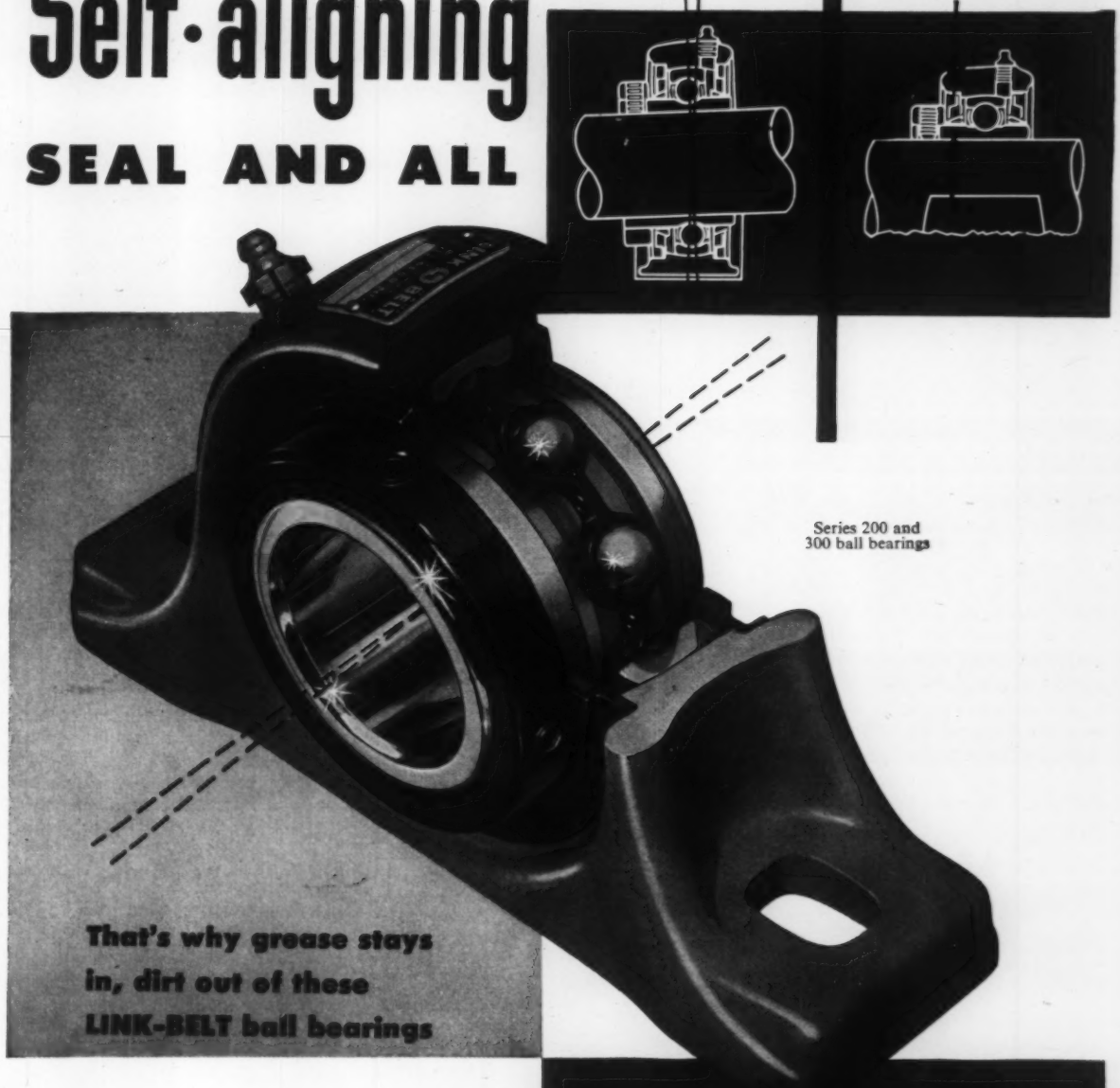
5. Check Recruiting Advertising

Where engineering recruiting advertisements are in fact institutional, responsible management will do well to seek their modification.

Self-aligning SEAL AND ALL

SELF-ALIGNMENT is assured because the lubricated, spherical outer ring is free to align in any direction. Full load capacity is always maintained regardless of shaft deflection or misalignment.

POSITIVE PROTECTION of the rolling elements from moisture, dust and dirt is provided by self-aligning seals extending from housing to inner ring. Large grease reservoir prolongs lubrication intervals.



Series 200 and 300 ball bearings

That's why grease stays in, dirt out of these LINK-BELT ball bearings

To compensate for supports and shafts that misalign in service . . . for unavoidable inaccuracies in mounting—Link-Belt offers self-alignment in ball bearings. And to protect that vital feature against dust and dirt, Link-Belt provides effective seals that *align along with rolling elements.*

Self-alignment is standard throughout industry's most complete line of ball and roller bearings—pillow blocks and flange, flange cartridge, cartridge and take-up units. Ask any one of 40 Link-Belt offices for Book 2550.

14.330-A

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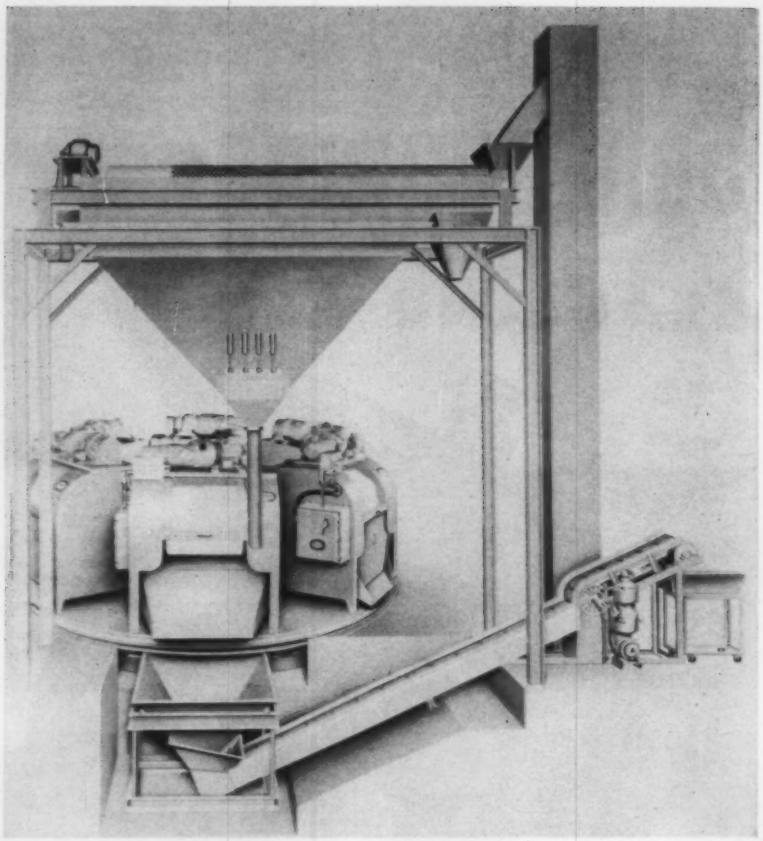
Army Helicopter Sets Three World Records

WICHITA, KANS.—Flying an Army YH-41 type Cessna *Seneca* helicopter on December 28, Capt. James E. Bowman set three new world helicopter altitude records. The record-breaking flights were conducted by the Army in co-operation with Cessna Aircraft Corp. and were under the supervision of the National Aeronautics Association. These records top previous records of 26,931 ft established by Jean Boulet of France, flying an SE *Alouette* helicopter on June 6, 1955.

Weight Category	Old (ft)	New (ft)
Unlimited—No weight restriction	26,931	30,335
Second—1102-2204 lb	26,931	30,335
Third—2204-3858 lb	None	28,200

During the first of two record-breaking flights, the helicopter, weighing in at 2109 lb, set world altitude marks for the second and unlimited weight categories. In a second flight later the same day, with fuel added to bring the weight of the helicopter to 2229 lb, Capt. Bowman established for the first time a world altitude record in the third weight category.



BARREL FINISHING SYSTEM makes it possible for one operator to handle six barrel-finishing machines. Mounted on a turntable and equipped with a "memory" device, the system was developed by Almco, Queen Products Inc. The new system automatically rotates completed work to a single operator station for loading and unloading parts, media, and compound.

PACKARD STATION WAGON for 1958 shows the familiar Hawk styling, characteristic of Studebaker-Packard's entire line. The Packard line also includes a two-door hardtop, four-door sedan, and the sports-type Packard Hawk. All models are powered by a 289-cu in. engine that develops 225 hp at 4500 rpm. Power brakes and Flightomatic transmission are standard equipment. The eight-passenger station wagon is mounted on a 116.5 in. wheelbase with an overall length of 206 in. A fold-away rear seat provides added cargo capacity.

Russians Call for 300% Instruments Increase by 1961

WASHINGTON—The Russians plan to increase by substantial amounts, averaging about 300 per cent, all types of electrical, mechanical, optical, radiation-measuring instruments and related instruments for automation. Based on information from the Russian journal *Measurement Engineering*, official USSR instrumentation periodical, the major objective of the 6th Five-year Plan, which began in 1956, is to increase their means of production by approximately 70 per cent and consumer goods by 60 per cent.

They seek to obtain the high degree of instrumentation for production precision, interchangeability, and engineering measurement. These plans were reported in a recent address given before the

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— if it's an MPB bearing — is exactly like any other of its kind, minted with magnificent, miniature precision.

If your money comes from making precision equipment, you'll want to know more about the profit-producing powers of Miniature Precision Bearings. These bearings improve instrument sensitivity and reliability — heighten values and often cut costs.

Now possibility and perfection can replace impossibility and imperfection. There are MPB bearings from ⅜" O.D. down — precise within limits one-third the thickness of a postage stamp! Despite its minuteness every ball in an MPB retainer-type bearing rolls in its own coined pocket. Even under extreme temperature changes MPB bearings run smoothly, helping your product deliver continuous precision and top performance.

If miniaturization can help you, so can MPB. Over 500 kinds of bearings — specials if you need them. And we are ready with the world's broadest miniature bearing experience (we own the mint!) to solve your problems and help you mint ideas. Write to Miniature Precision Bearings, Inc., 102 Precision Park, Keene, N. H.

MPB

MINIATURE PRECISION BEARINGS

Circle 416 on Page 19

Savannah Statistics

For construction of the world's first nuclear-powered merchant ship, the *NS Savannah*, a $21-million contract has been awarded to the New York Shipbuilding Corp. by the Maritime Administration and the Atomic Energy Commission. The contract provides for construction of the passenger-cargo ship and for installation and testing of the ship's nuclear propulsion system. The schedule calls for keel laying in 1958, launching in 1959, and operation on the high seas in 1960.

Operation of the ship's entire power plant will be remotely controlled from a single console located in a control room. Provisions in design of the ship include accommodations for 60 passengers as well as 130 crew members, and permit tours of visitors to view the ship's machinery in operation. The nuclear power plant of the ship will be of an advanced pressurized water design, the propulsion equipment being a steam turbine connected to a single propeller shaft through double reduction gears.

Length over-all (approx.)	587 ft 6 in.
Length between perpendiculars	545 ft
Beam	78 ft
Depth to *A* deck	50 ft
Depth to *B* deck	41 ft
Design draft	29 ft 6 in.
Light ship	11,650 tons
Cargo	9340 tons
Full load displacement	21,840 tons
Cargo bale cubic	754,000 sq ft
Design sea speed	20¼ knots
Emergency (take home) speed	6 knots
Normal shaft hp	20,000
Max cont shaft hp	22,000
Number of propellers	1
Normal cruising radius	350,000 miles

Business Advisory Council of the Department of Commerce by A. V. Astin, director of the National Bureau of Standards.

According to Mr. Astin, the development of technology depends upon control of interchangeable parts with greater reliability and precision. There is a pressing need today to control the tolerances of many important and critical elements such as fuel injectors, bearings, gyroscopes, and transistors to tolerances expressed in hundred-thousandths or even millionths of an inch. A leading expert of precise measurement, Mr. Louis Polk, President of the Sheffield Corp. has stated, "Our progress continues to be limited by our ability to

ULTRALIGHTWEIGHT DESIGN will be applied to Army's armored personnel carrier. Under terms of recently awarded contract, Dow Chemical Co. will build a magnesium hull for this vehicle from experimental magnesium alloy only about half the weight of aluminum. Planned version of vehicle will weigh less than one-third as much as comparable steel armored carriers now in use; represents advance of air-transportable ground vehicles.

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The guiding genius of true automatic control — of superhuman functional speed, uniformity and accuracy—is a man-made cam. And back of this mechanical brain are the inventive minds and skilled hands of engineers and craftsmen such as those at Parker. A pioneer in the field of *3-dimensional cams*, Parker has complete facilities for design and development assistance as well as prototype and production manufacture—plus an enviable reputation for precision and leadership in the creation of cams that can make machines repeat the most exacting operations—without the possibility of human error.

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split the inch into smaller and smaller portions."

"In Russia," Mr. Astin said, "The entire program of instrument development and production, as well as the means of utilizing effectively their new instruments is under a Committee on Standards, Measures, and Measurement Apparatus of the Council of Ministers of the USSR. Five research institutions work directly for this Committee on new and improved techniques for physical measurement and on the development and maintenance of the basic standards for measurements.

"Operating under the supervision of these institutes is a network of calibration centers. Their Plan calls for 129 such centers by 1960. A major function of these calibration centers is to evaluate and approve all of the measuring instruments used in any Russian production plant. One of the available reports includes an item chastising industry for not measuring up to new precision standards and urging that greater authority be lodged in the regional calibration centers so that they will not only pass on the precision characteristics of the instruments but also upon the way they are used in industrial plants.

"Another function of the calibration centers is to make available to industry the latest advances on new measurement techniques derived from the research institutes. This is indeed a substantial chain to insure not only that new measurement techniques are developed and made available but also that they are used effectively."

Mr. Astin continued by describing NBS efforts as being far more limited than those of the Russians. He drew a comparison of Russian measurements at 6000 C with plans to extend this competence to 12,000 C as compared with NBS capabilities for making measurements at only 2800 C, and by impromptu means at 4200 C.

"I believe that the Bureau's essential measurement research activities must be substantially strengthened," Mr. Astin said. "They must be reviewed in terms of both the ominous Soviet challenge and of effective domestic technological expansion. Quite

30 SECOND QUIZ

1. Given a properly cleaned gray iron casting, does aging it outdoors several months improve machinability or not?
   ☐ Quite a bit ☐ A little ☐ Makes no difference
2. Gray irons are available under standard specifications with tensile strengths from 20,000 psi to _____ psi.
3. Ductile iron castings may be purchased under standard specifications with strengths as high as _____ psi.
4. What is the maximum temperature at which a high strength gray iron casting can maintain its load carrying ability?
   _____
5. To get the needed strength, finished automotive crankshaft castings would have to be approximately how much heavier than finished forgings?
   ☐ 50% heavier ☐ 20% heavier
   ☐ 10% heavier ☐ no heavier

NOW turn upside down for answers

1. Makes no difference.
2. Standard "specs" go up to 60,000 psi.
3. A 120,000 psi is available with heat treatment.
4. Non-pressure applications up to 800° are used.
5. Cast crankshafts may actually be lighter than forged.

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TIMES TO DESIGN WITH GRAY IRON CASTINGS

Circle 418 on Page 19

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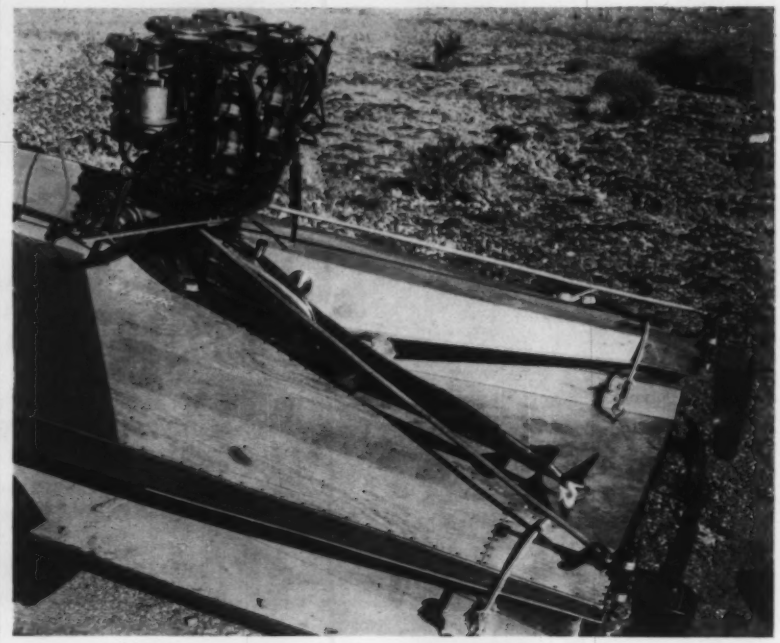
Circle 419 on Page 19

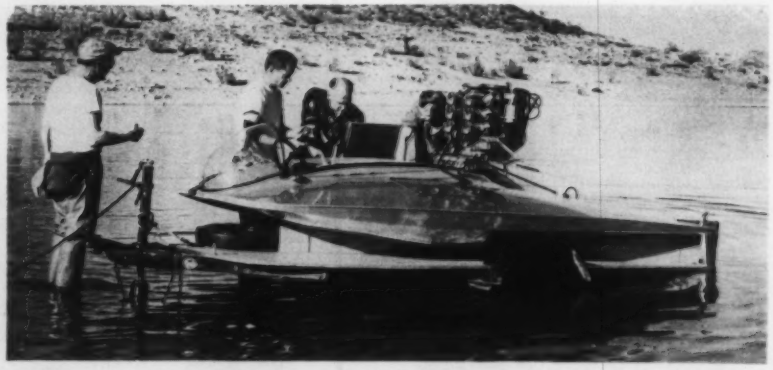
apart from any direct comparison between Soviet competence and our own, we know of several areas where our inability to provide requested measurement standards services is impeding the work of scientists and engineers in other laboratories."



Business end of 12½-ft, twin-hull outboard hydroplane shows several of its unique features. The mammoth power head consists of two 3-cylinder outboard motors geared up to deliver 120 hp and speeds of 8500 to 11,000 rpm to the bronze, two-blade Stannus surface propeller. The lower unit (center) contains an extension shaft that projects 4½ ft to the rear of the vertical drive shaft. This steel shaft tapers from 1 in. at the powerhead to ⅜ in. at the propeller and is supported on four bronze bearings in an aluminum housing with three built-in stabilizers.

Seek Speed Record In Twin-Hull Outboard

LAKE MEAD, NEV. — An outboard motor manufacturer has notified the National Outboard Association that it will attempt to set a new speed record for an outboard hydroplane in the United States. The record-breaking attempt for the Scott-Atwater Mfg. Co. will be

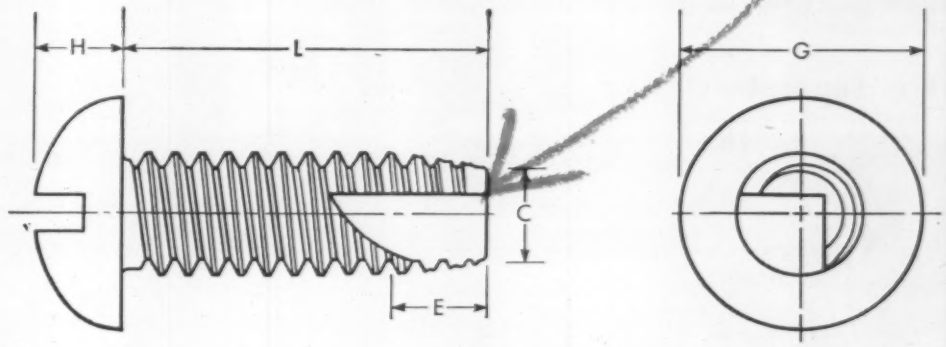


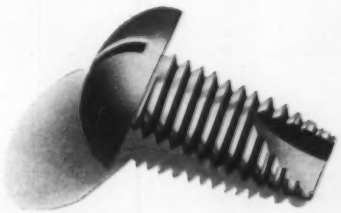
Engineers give the *Flying Scott*, twin-hull outboard hydroplane which will attempt to set a new all-time American outboard speed record a final, in-the-water check before she's launched on a trial run at Lake Mead, Nev.

THREAD-CUTTING SCREWS

TYPE 23

ELIMINATES TAPPING—
CUTS COST 33%





GET TESTING SAMPLES FROM

FUNCTION: SHAKEPROOF Type 23 Thread-Cutting Screws cut perfectly mated threads in metal, die castings and plastics.

VARIATIONS: Type 1 Thread Cutting Screw has narrow slot and standard thread for certain hard metal applications; Type 25 for plastics has spaced thread and large cutting slot.

SPECIAL FEATURES: Pilot points, enamel-reaming points, double-end studs, headed shoulders. Thread-Cutting Screws can be pre-assembled with lock washers, fiber washers, flat washers, special stampings. Sealing compounds available.

HEAT TREATMENT: Special heat treating makes SHAKEPROOF Thread-Cutting Screws twice as strong as ordinary screws, often reduces the number or size of screws required.

REMARKS: Thread-Cutting screws reduce fastening cost as much as ⅓ by eliminating tapping operation. Ideal for use with automatic hopper-fed power screw drivers.

HEAD STYLES: All popular styles available including slotted, Phillips recess, hexagon and hexagon washer heads. Many special heads.

MATERIALS: Steel, stainless steel, aluminum, brass.

FINISHES: Cadmium plated, plain, parkerized or other finishes as specified.

DRAWN BY:		CHECKED BY:	
RDC	1/1/58	RMW	1/1/58

NOTE: Type 1 and Type 23 Thread-Cutting Screws cut a standard machine screw thread, can be removed and reused. Patented.

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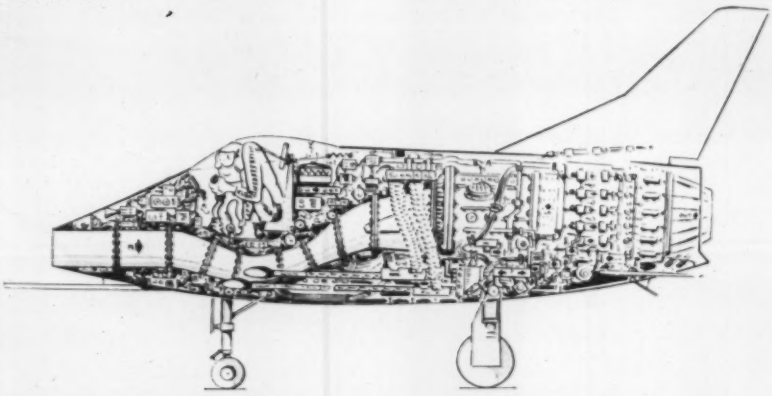
Circle 421 on Page 19

made as soon as weather permits.

Danny Foster, noted Detroit racer, will drive the Flying Scott, a 12½-ft twin hulled Fillinger hydroplane powered by two 3-cylinder, 60-hp motors coupled to a radically new lower unit, over a one-mile course. The run will be timed by the National Outboard Association.

According to the company, the fastest speed any outboard hydroplane has ever reached in this country is 85.106 mph. The equipment for the coming test was especially developed with William Tenney, famous outboard racer, acting as consultant during the development work. The equipment includes a new type of twin-hull hydroplane; a power unit based on modification of two Scott-Atwater 60-hp, three-cylinder motors; new lower unit; and a special steering and control system designed for this hull and motor combination.



REDESIGNED PILOTS would solve some of the increasing problems in design of high-mach aircraft. This illustration from an SAE paper by Robert R. Janssen, North American Aviation, emphasizes problems in design of high-temperature electronic equipment. To date, this equipment has required considerably more space than low-temperature apparatus. Since 1 cu ft of space equals about 100 lb of finished aircraft, limitations are necessary. According to Janssen, size and weight of high-temperature electronic components for coming generation of aircraft must not exceed 15 to 30 per cent of present equipment, or separate cooling will be needed.

Meetings

AND EXPOSITIONS

March 3-6—

American Society of Mechanical Engineers. Gas Turbine Power Div. conference and exhibit to be held at the Shoreham Hotel, Washington, D. C. Further information is available from Mr. Barry Freer, 1300 Connecticut Ave. N. W., Washington 6, D. C.

March 4-6—

Society of Automotive Engineers Inc. Passenger Car, Body and Materials Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 11-14—

Pressed Metal Institute. Spring Technical Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information is available from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

March 17-18—

Steel Founders' Society of America. 56th Annual Meeting to be held at the Drake Hotel, Chicago. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 17-20—

American Society of Mechanical Engineers. Aviation Div. Confer-

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C. Arthur Weaver, Richmond, Virginia
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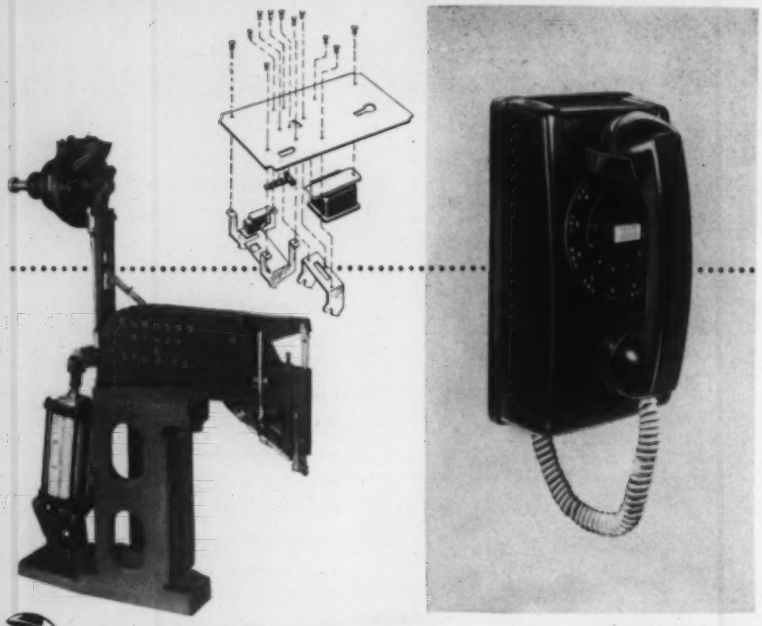
SPEEDS FASTENING BY 60%



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Maximum Efficiency Requires Flexibility

A substantial reduction in the cost of assembling components of the wall-phone base-plate resulted when engineers from Western Electric's Indianapolis Works and ***Tubular*** solved a fastening problem — they developed a Multi-Head Riveter assembly consisting of 11 automatic, air-operated machines. A bank of 5 riveters was joined to a 6-machine bank by a bridge with a rolling fixture. This method replaced the preliminary fastening plan which was based on 40 operations, 2 machines and 2 operators. The new Multi-Head assembly reduced estimated fastening labor costs about 35%. When production requirements increased tremendously, an additional nominal investment modified the bridge and added a second rolling fixture. Two operators were then easily able to boost the production rate an additional 60%.

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Western Electric, manufacturing and supply unit for the Bell System, produces telephones, wire and cable, switching systems; and in addition, makes important contributions to defense projects such as DEW Line and Nike Guided Missile Systems.

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ence to be held at the Statler-Hilton Hotel, Dallas. Additional information can be obtained from ASME headquarters, 29 West 39th St., New York 18, N. Y.

March 17-21—

National Association of Corrosion Engineers. Fourteenth Annual Conference and Exhibition to be held at the Civic Auditorium, San Francisco. Further information is available from association headquarters, 1061 M & M Bldg., Houston 2, Tex.

March 17-21—

1958 Nuclear Congress, to be held in conjunction with the Atomfair of the Atomic Industrial Forum at the International Amphitheatre, Chicago. More than 30 organizations sponsor the Congress, which is co-ordinated by the Engineers Joint Council, 29 W. 39th St., New York 18, N. Y.

March 24-27—

Institute of Radio Engineers. National Convention to be held at the Waldorf-Astoria Hotel and the Coliseum, New York. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

March 31-April 2—

Society of Automotive Engineers. Production Meeting and Forum to be held at the Drake Hotel, Chicago. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

"Hope you haven't destroyed that drawing yet, Mentz. We've changed our . . . MENTZ!"

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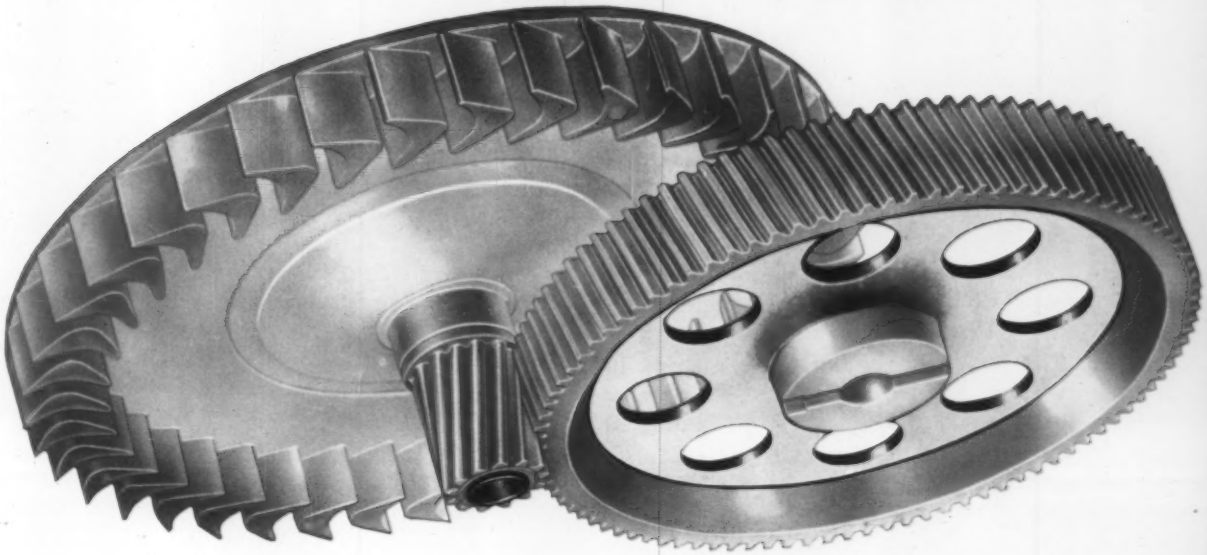
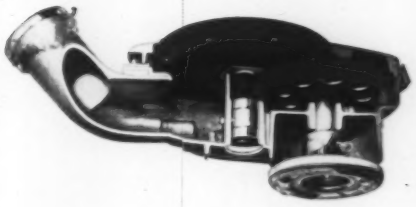
Circle 424 on Page 19→

DU PONT

PRODUCT ENGINEERING NEWS

Turbine wheel of ZYTEL® nylon resin runs new vacuum-powered tool





TURBINE WHEEL AND DRIVE GEAR molded of ZYTEL nylon resin power the new *Turbotool*® attachment for Electrolux vacuum cleaners. (Molded by Westplex Corp., Rochester, New York, for Electrolux Corporation, New York, New York.)

A simple turbo-motor runs the home-workshop attachment used with the Electrolux vacuum cleaner. Indrawn air rotates the 4" turbine of ZYTEL at high speed. Power at the chuck head is said to be greater than for most household electric drills. Centrifugal stresses are far less than for a metal construction, due to the low specific gravity of the material (1.14).

ZYTEL can be molded to the high-precision dimensional requirements of the turbine. The buckets mold clean, smooth and true—without flash. A projecting drive pinion of ZYTEL and a metal shaft insert form part of the turbine wheel. The large gear driven by the turbine is also molded of ZYTEL around a metal web.

Mechanisms that would require an assembly of many parts if made of other materials, are often molded from ZYTEL nylon resin as a single part, requiring no finishing operations. Injection molding of ZYTEL produces precise, complicated parts on a mass production scale . . . and at low cost. Components made of ZYTEL are extremely strong and very resistant to wear. They display excellent heat and impact resistance. Little or no lubrication is needed for smooth operation.

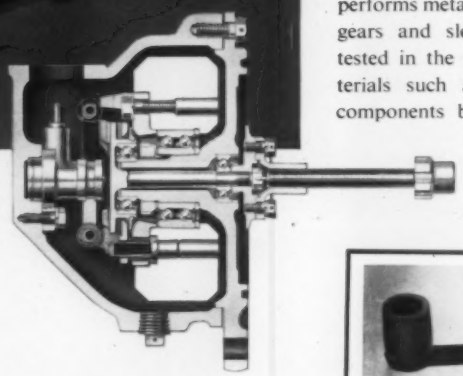
Learn how Du Pont ZYTEL can help you reduce the cost of your new appliance designs. Return the coupon for the facts on its wide range of properties and uses.

OVER

DU PONT

PRODUCT ENGINEERING NEWS

Durable parts of Du Pont ZYTEL® nylon resin improve operation of train braking device



BRAKE CONTROL MECHANISM mounted on the axles of railroad trains prevents wheel skidding. By automatically regulating brake pressure, it provides maximum braking by preventing the wheels from locking. Parts redesigned with abrasion-resistant ZYTEL eliminated a problem of fretting corrosion, thus insuring proper electrical contact in the unit. Above—new leaf springs, guide pin assemblies and locator pins made with ZYTEL. Shown at right—"Rolokron" axle unit by The Budd Company, Philadelphia, Pa.

Problem of fretting corrosion and faulty contacts eliminated

A vital train braking device sometimes failed to function due to improper electrical contact. This was traced to a heavy accumulation of "red dust," which is the residue of fretting corrosion. The trouble was overcome by redesigning the parts whose minute movements were the source of the corrosion. Using Du Pont ZYTEL nylon resin, metal-to-metal rubbing contacts were eliminated. ZYTEL proved itself in service, providing extremely high wear resistance and good electrical insulating properties.

ZYTEL has the highest strength-to-weight ratio of any resin. It often outperforms metal parts. For instance, both gears and sleeve bearings of ZYTEL, tested in the presence of abrasive materials such as sand, outwear metal components by far. Mechanical parts of ZYTEL are highly resistant to blows and shocks . . . need little or no lubrication.

PIPE STEMS are molded of ZYTEL in natural, white, black and metallics. Practically unbreakable, the stems are threaded to accept a variety of bowl shapes. ZYTEL is rated for intermittent operation up to 250° F. For continuous operation at such elevated temperatures, heat-stabilized grades are available. (Molded by Boonton Molding Co., Boonton, N.J., for National Briar Pipe Co., Jersey City, N.J.)

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SEND FOR INFORMATION

Mail this coupon for property and application data on Du Pont ZYTEL nylon resin.

FORGED INSET

Flash Butt-Welded Into a Stainless Ring

SAVES MATERIAL, TIME, and MONEY

By welding a forging into a circled section of an extruded shape, American Welding saved one jet engine manufacturer over 200 lbs. of AMS-5613 stainless steel per ring. Hours of machining time were also eliminated. The finished ring met both government and prime contractor's specifications. Savings per ring were very substantial.

This is a typical example of how American Welding's experience in forming and welding of stainless, aluminum, titanium and heat-resistant alloys has helped others cut production costs — and may be able to help you.

If your problem is circular and of metal — call American Welding first.

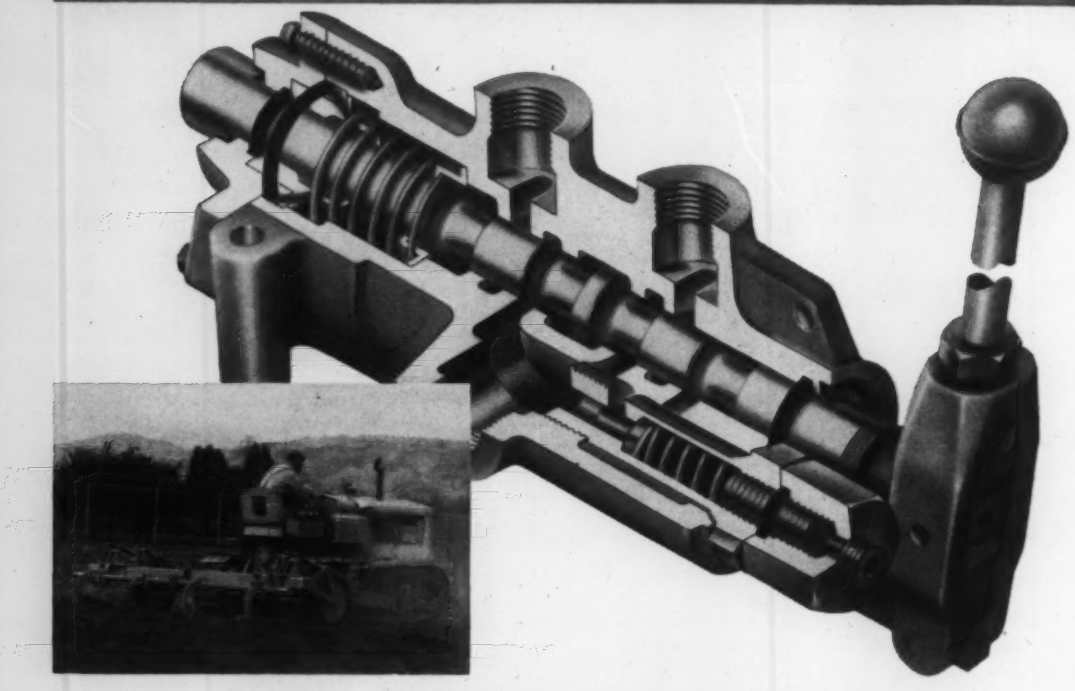
NEW PRODUCTS CATALOG AVAILABLE

Write today for 20-page catalog illustrating the many types of circular products American Welding can form, weld and machine for you.

AMERICAN WELDING

THE AMERICAN WELDING & MANUFACTURING CO.
130 DIETZ ROAD • WARREN, OHIO

NATIONAL OIL SEAL LOGBOOK



Use of O-rings as moving seal in heavy duty bulldozer control valve

1,500 psi variation without backup rings. Intermittent operation plus long periods of inactivity. Extreme external dust and dirt conditions. Irregular and unpredictable field servicing. Fluid oil temperatures reaching 180°F. Climatic temperature extremes from —30° to +120°F. Life expectancy is required to be that of the tractor.

Above are the rugged operating conditions faced and met by National industrial O-rings in the new Be-Ge Model SU-1200F bulldozer blade control valve. A total of four rings are employed in each unit; two in a moving shaft application and two as static seals.

Be-Ge reports no leakage or ring failure on hundreds of heavy duty applications involving Oliver, Caterpillar, International Harvester and other crawler tractor installations.

National offers a complete line of industrial O-rings, plus many exclusive compounds. Special compounding is also available to meet unusual conditions.

For complete information on National O-Rings, or for skilled O-ring engineering service, call your nearest National Seal engineer. In major cities nationwide. See the Yellow Pages, under "Oil Seals".

Syntech® Oil Seals

Syntech oil seals, developed by and offered exclusively by National, are widely used synthetic rubber seals for applications where temperatures reach 250°F, speeds reach 3,600 FPM, and total indicator runout is as high as .030. Basic 50,000 series Syntech (illustrated) employs a tough, accurately manufactured steel outer case, precision-tensioned spring and accurately molded and trimmed Syntech sealing lip.

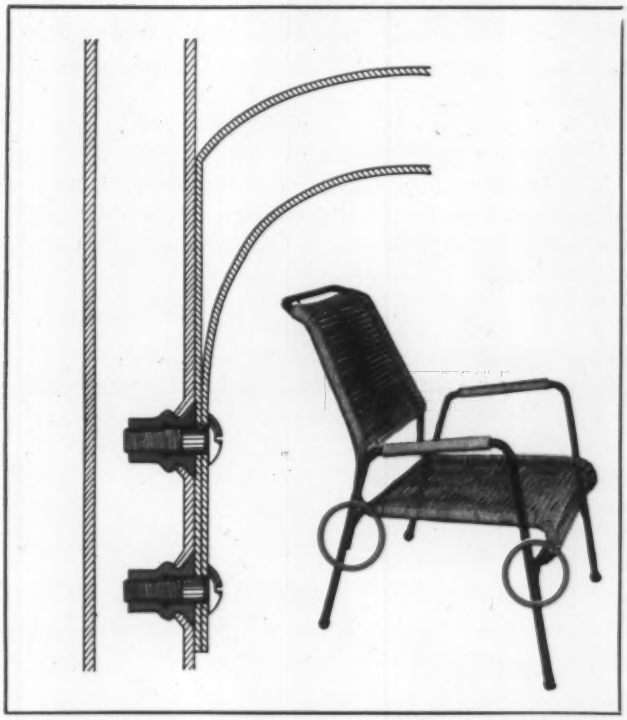
Micro-Torc Oil Seals

Micro-torc oil seals, pioneered by National, are sturdy, dependable leather seals. Special elastomer coating on *surface* of chrome re-tanned leather sealing lip prevents seepage of oil. Yet inner body of sealing lip retains natural porosity to "store" lubricant against accidental periods of starvation. Inherent lubricity of elastomer coating produces a lower torque, longer lasting, economical oil seal. Available in a wide variety of types and sizes.

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio, Redwood City and Downey, California

4624

Only B.F.Goodrich Rivnuts® give you firm, blind nutplates for tubular applications!



Finding a fastener that would preserve the clean, functional lines of their modern tubular furniture was a problem for the O. Ames Company. Stove bolts and screws projecting from the legs were not only unsightly, but were a major sales deterrent to a woman in 51 gauge nylons.

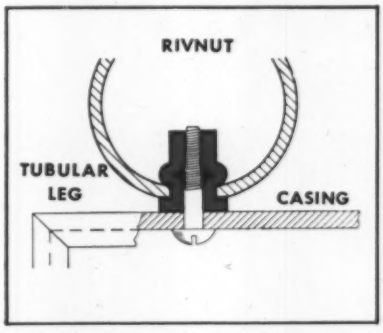
B. F. Goodrich Rivnuts provided the answer to this problem. Upset inside the tubular legs, Rivnuts with countersunk heads fit flush, take round headed attachment screws. In addition, Rivnuts hold firmly and permanently because the bulge in the Rivnut shank conforms to the curvature of the tube. Rivnuts are installed by one man in seconds, and provide an accurate nutplate for quick assembly of the finished product.

If you want to do a smoother fastening job, or are looking for ways to fasten faster and at less cost, use B. F. Goodrich Rivnuts.

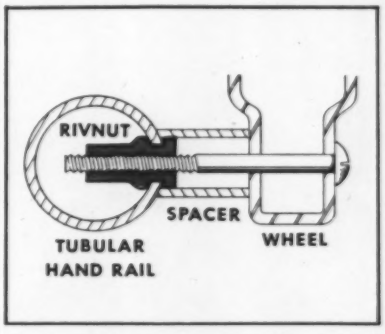
SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to B. F. Goodrich Rivnuts, Dept. MD-28, Akron, Ohio.

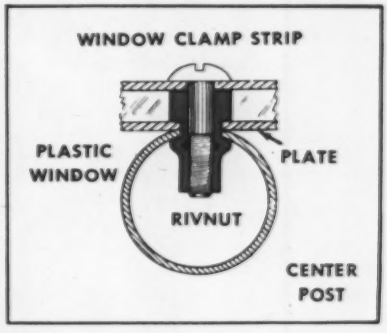
Rivnuts solve a variety of tubular fastening problems like these



Switching to Rivnuts speeded assembly of barbecues. One man installs a Rivnut in the tubular leg in seconds. There are no boltheads to detract from the unit's clean lines. Time is saved in faster knockdown for shipping.



Designers of a wheel chair needed a blind fastener with at least 6 clean threads to serve as a nutplate. Rivnut upset inside the tubular handrail of the wheel chair provides firm, accurate, nutplate for bolt attachment to the wheels.



Upset Rivnut secures airplane window plate to center post. Firm bulge in shank seals weather out. Rivnut head serves as spacer for plastic window, while 6 clean threads hold clamp strip and window securely in place.

B.F.Goodrich

B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio

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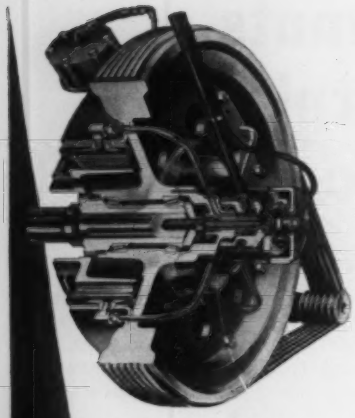


FSPA* provides improved performance without costly new equipment

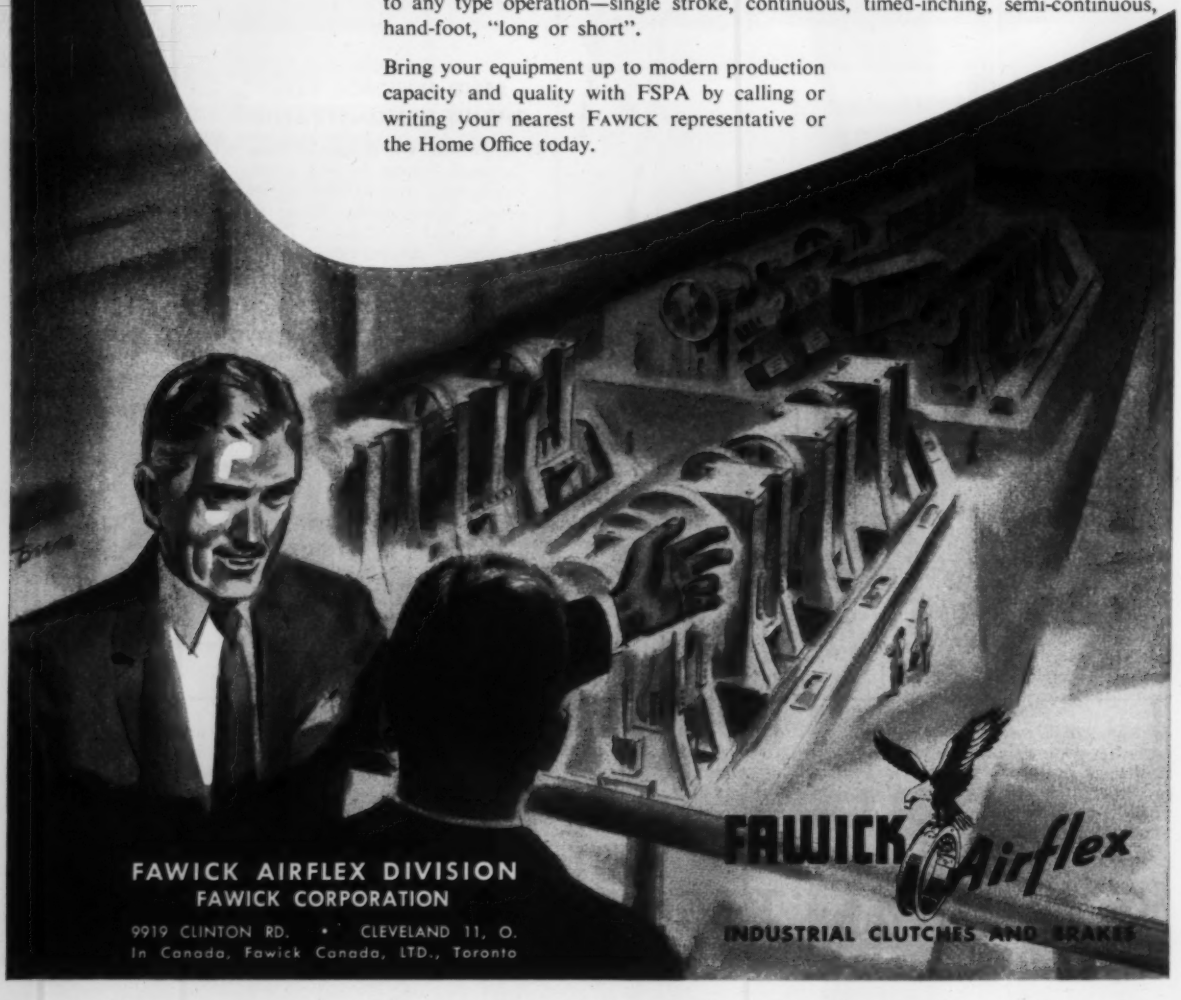
FSPA has given Production Management a practical and economical answer to the problem of increasing the efficiency and productivity of existing equipment—without costly capital expenditure for new equipment.

Hundreds of users report: "The FAWICK STANDARDIZED PRESS APPLICATION has provided us with the most modern advantages, including the following:

- **INCREASED AND IMPROVED PRODUCTION** through full operating power, accurate cycle-timing, precise control, and positive braking action.
- **MAXIMUM PROTECTION TO PRESSES, DIES, AND OPERATORS** through dependable clutch and brake operation, and overload protection.
- **SIMPLE LOW-COST INSTALLATION** with complete package units and full installation instructions. Simple machining prepares crankshaft for fast installation.
- **SELECTIVITY** through FAWICK Timing Rotorseal and high-speed Clutch Control to any type operation—single stroke, continuous, timed-inching, semi-continuous, hand-foot, "long or short".

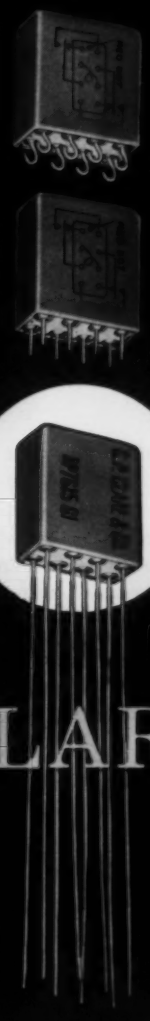
Bring your equipment up to modern production capacity and quality with FSPA by calling or writing your nearest FAWICK representative or the Home Office today.

*Fawick Standardized Press Applications are complete pneumatic Clutch and Brake package applications for low-cost modernization of O.B.I., straight-side and back-geared presses.



FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON RD. • CLEVELAND 11, O.
In Canada, Fawick Canada, LTD., Toronto

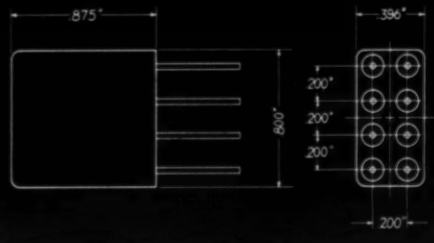
FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES



Smaller than a postage stamp!

(except in thickness, of course)

—the *new* CLARE *Type F* RELAY



SPECIFICATIONS:

Ambient Temperature	—65° C to +125° C.
Shock	50 Gs for 11 milliseconds.
Vibration	5-75 cps at maximum excursion of ¼-inch, 75-2000 cps at 20 Gs acceleration.
Dielectric Strength	Sea level—1000 volts rms between terminals and frame, and between adjacent circuits; 750 volts rms between contacts of a set. At 80,000 ft., 350 volts rms.
Insulation Resistance	1000 megohms minimum at 125° C.
Coils	Coils up to 10,000 ohms available for a wide range of voltages or currents.
Nominal Operating Power	250 milliwatts.
Pickup Time	3.5 milliseconds nominal.
Dropout Time	1.5 milliseconds nominal.
Contact Arrangement	2 pdt (2 form C).
Contact Rating	3 amps resistive at 28 volts d-c or 115 volts a-c; also for low-level applications.
Contact Resistance	0.050 ohm maximum.
Contact Life	500,000 operations minimum at 2 amps; 100,000 operations minimum at 3 amps.
Enclosure	Hermetically sealed, filled with dry nitrogen at 1 atmosphere pressure.
Mounting	All popular mounting arrangements available.
Terminals	Printed circuit; solder; plug-in (matching socket available). Variations of printed-circuit terminal length on 1/10-inch grid spacing available.
Weight	17 grams.
Military Specifications	MIL-R-25018; MIL-R-5757C, except as to contact overload.

This new hermetically sealed relay—no bigger than a postage stamp—is Clare's response to the insistent demand of the military and of industry for a smaller and lighter relay stalwart enough to withstand extremes of temperature, heavy shock, and severe vibration, yet fast and more than moderately sensitive.

Without any assertions of superior design, materials or workmanship, the factual specifications at the left tell how closely this relay is geared to the needs of today's advanced circuit designers. Important to many engineers will be the fact that the contacts—rated at 3 amperes—are proven also for low-energy-level circuit applications. Designers of printed-circuit layouts will note that the terminal arrangement is nicely suited to 1/10-inch grid spacing.

For complete information send for Bulletin 124. Write or call: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: C.P.CLARELAY.

CLARE RELAYS

FIRST in the industrial field

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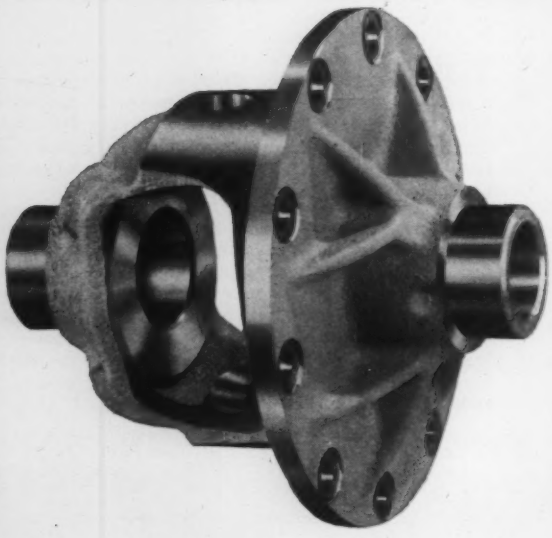
how ARMASTEEL wider scope of

NEW PRODUCT DESIGNS POSSIBLE . . . Due to their unusual physical properties, high machinability ratings, and wide latitude of design, ArmaSteel castings are replacing other materials in today's products. Being a casting material, ArmaSteel can be formed in shapes too complex for the forging process. With ArmaSteel castings, low draft angles, intricate coring, and close dimensional tolerances are possible. Less stock remains to be machined. High tensile strength, damping qualities, and other physical and chemical characteristics are also major factors in ArmaSteel's popularity among product design engineers.

ARMASTEEL IS A PEARLITIC MALLEABLE IRON, possessing many of the physical characteristics of forged low-carbon steel. Because of carbon nodules in the pearlite matrix, the machinability of ArmaSteel castings is 58% better than S.A.E. 1040 steel and compares favorably with S.A.E. 1112. ArmaSteel is produced in three ranges, with tensile strengths from 70,000 psi to 100,000 psi, yield strengths from 48,000 psi to 80,000 psi, and elongations (in 2") from 2% to 4%. Because of these excellent properties, and because it can be either sand cast or shell cast, ArmaSteel provides improved parts for many products, at the same time that it lowers costs. On these pages are two case histories of products that have benefited from ArmaSteel castings . . . perhaps your product can benefit too.

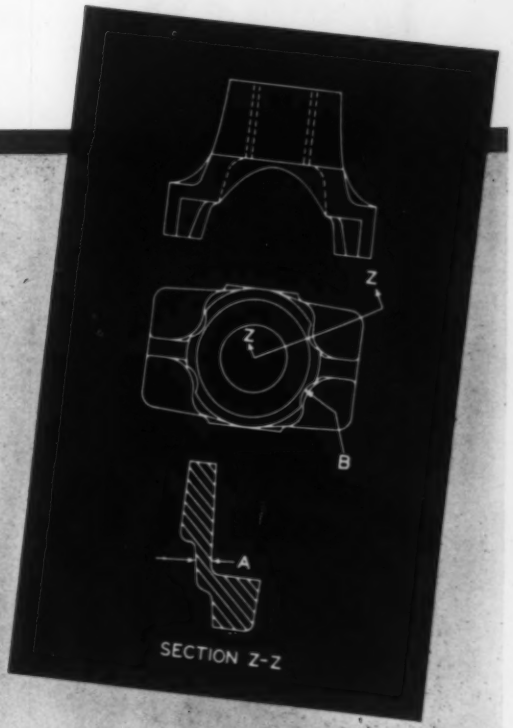


CAST ARMASTEEL IMPROVES AN AUTOMOBILE DIFFERENTIAL CASE

This case forms the support for the driving gears in an automobile. The demands made of such a part are that it be of high strength, that it have the least possible deflection, and that—because it is part of the car's unsprung weight—its weight be held to a minimum to help the riding characteristics. The part must be cast because it is impossible to forge the internal cavity.

ARMASTEEL 86M MET ALL THESE DEMANDS. It has a tensile strength of 70,000 psi, a yield strength of 48,000 psi, and a Brinell Hardness No. of 163-207. Deflection is very low, and ArmaSteel absorbs vibrant energy, thus contributing to quiet operation. The cast ArmaSteel part also allowed the manufacturer to eliminate thrust washers on the pinion gear bearings, reducing costs.

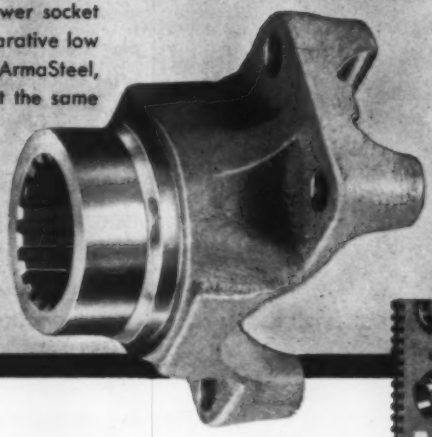
castings allow new and much design



CAST ARMASTEEL REPLACES FORGINGS IN THIS COMPANION FLANGE BECAUSE OF SPACE LIMITATIONS

This part was formerly a medium carbon steel forging. During a re-design of the unit, it was impossible to get the desired strength by enlarging the part, because of design limitations. It became apparent that the draft angles necessary in the forging would not allow proper thickness of metal at point "A". Only a casting could achieve the low draft angles needed, and only a high strength material could meet the design requirements.

CASTINGS OF ARMASTEEL 84M PROVIDED THE ANSWER. ArmaSteel 84M has an ultimate tensile strength of 100,000 psi, and a yield strength of 80,000 psi. ArmaSteel parts tested showed a long fatigue life and minimum deflection under the extreme stress involved. In addition, castings offered a reasonable cost per piece, excellent machinability, and uniformity in production lots. In broaching the spline in the center hole, the manufacturer found that ArmaSteel castings resulted in greatly improved broach life. Draft angles were reduced to 2°, which allowed sufficient clearance (point "B") for the power socket wrench assembly operations. Thus, due to the comparative low cost of castings and the reduced machining costs of ArmaSteel, the manufacturer enjoyed an overall saving and at the same time solved his design and assembly problems.



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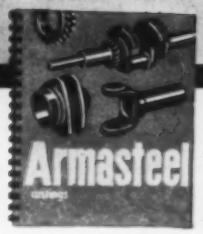

For further information on physical properties and applications of ArmaSteel, write for our complete catalog. Descriptive literature is also available on our shell mold and sand casting processes.

CENTRAL FOUNDRY DIVISION · GENERAL MOTORS CORPORATION

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

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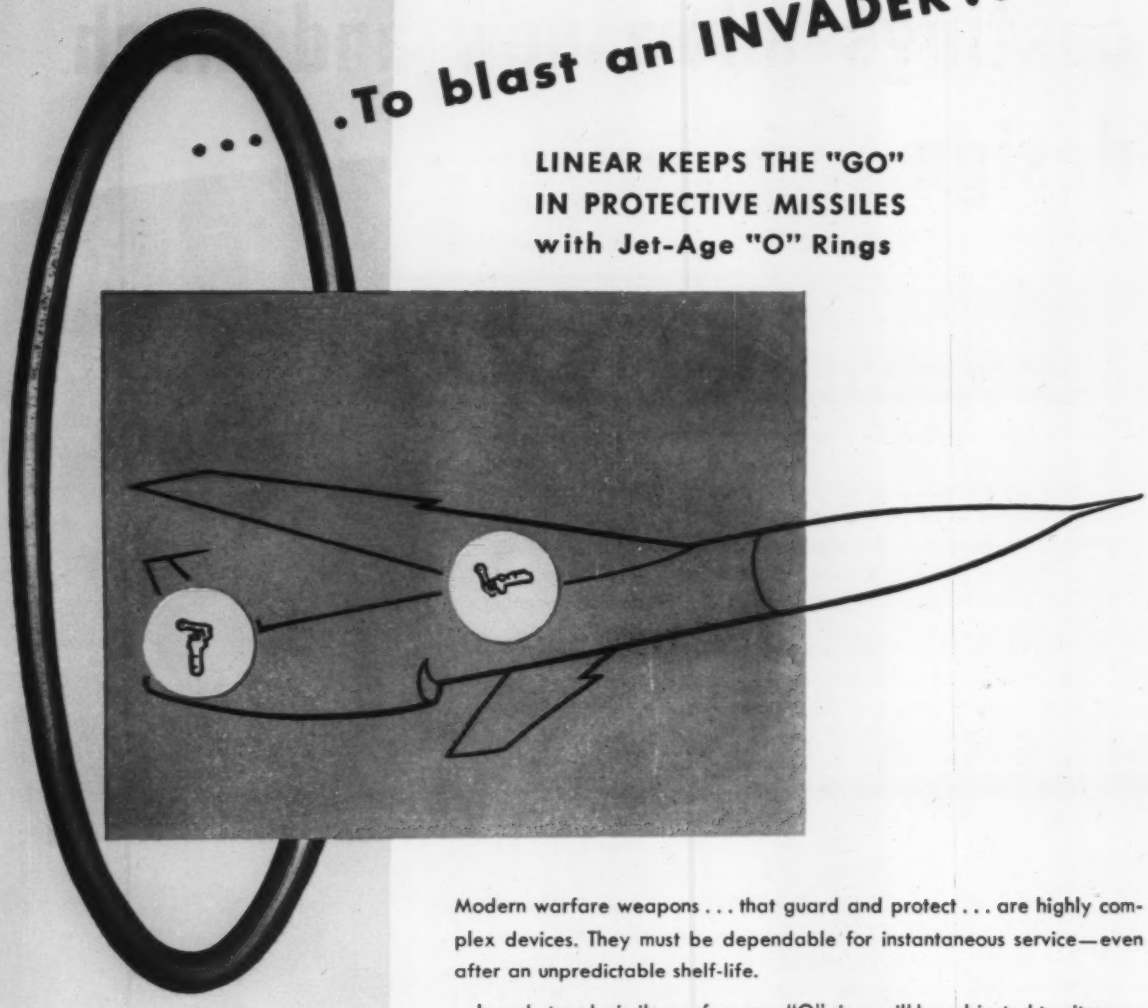
. . . To blast an INVADER . . . .

LINEAR KEEPS THE "GO" IN PROTECTIVE MISSILES with Jet-Age "O" Rings



Modern warfare weapons . . . that guard and protect . . . are highly complex devices. They must be dependable for instantaneous service—even after an unpredictable shelf-life.

In rocket and missile warfare use, "O" rings will be subjected to nitrogen, JP-4, ethylene oxide, hydrogen-peroxide, alcohol, liquid oxygen, fuming nitric acid, and other destructive environments. "O" rings are used in the servo-systems for flight control of guided missiles, and must withstand extremes in temperatures and the destructive actions of synthetic fluids.

LINEAR's experience in the design and production of precision "O" rings —of the most modern elastomers—has given them the ability to provide dependable seals for the most critical requirements.

When it's a sealing problem, call on LINEAR or one of its agents for engineering assistance . . .

and be sure to specify LINEAR "O" Rings for prototype or production.

"PERFECTION IN RUBBER"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Circle 431 on Page 19

Norgren AUTOMATIC-DRAIN Air Line Filters

Better Protection for Your Air Equipment

- **Now—30 Models to Choose From**—Transparent and metal bowls—¼", ⅜", ½", ¾", 1".
- **Removal of Corrosive Liquids is Highly Efficient**—Efficiency has been increased—even at air flows up to 143% higher than most filters available today.
- **Damaging Solids Are Removed**—Choice of interchangeable 74, 64 or 25 micron filter elements.
- **Wide Operating Pressure Range**—Top efficiency at as low as 5 psi. As high as 250 psi for metal bowl type.
- **Wide Operating Temperature Range**—Metal bowl models extend temperature range to 200° F.
- **Will Withstand Rough Usage**—Metal bowl models are ideal for applications likely to get rough usage.
- **Eliminates Cost of Manual Draining**—Collected liquid is drained automatically as long as pressure is on the system.

For complete information, call you nearby Norgren representative listed in your telephone directory—or WRITE FACTORY FOR NEW No. 900 CATALOG.

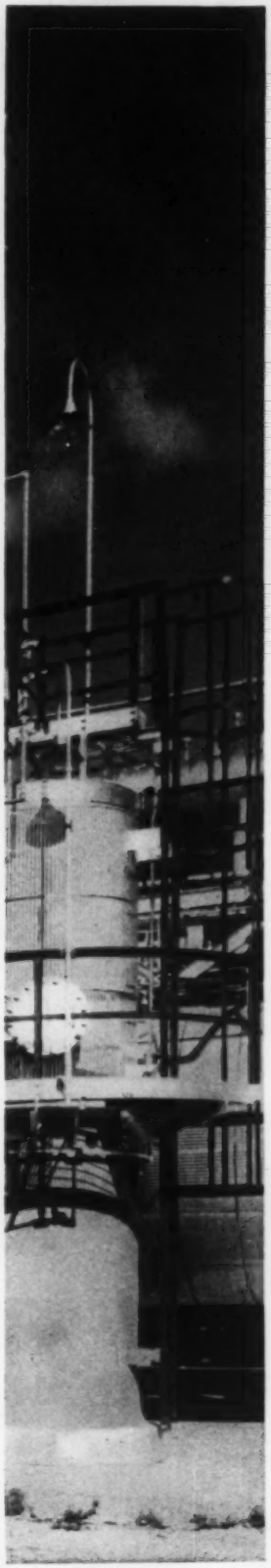
C. A. NORGREN CO.

3442 SOUTH ELATI STREET ENGLEWOOD, COLORADO

Circle 432 on Page 19

W. R. Grace & Co.'s 50,000,000 pound

high density polyethylene plant now in commercial production



* Multi-million dollar facility to produce GREX, the new high strength plastic resin.

* W. R. Grace & Co., Polymer Chemicals Division, reports GREX substantially improved over other resins, promising new horizons for plastics.

W. R. Grace & Co., Polymer Chemicals Division, recently put into commercial operation its multi-million dollar plant at Baton Rouge, Louisiana. First product is GREX, brand-new high density polyethylene. 50,000,000 pound annual capacity makes this the world's largest plant of its kind to come on stream as an integrated operating unit.

For several months, plastic fabricators have been testing and evaluating quantities of GREX with excellent results. Now, with this new plant, GREX is immediately available for large-scale commercial application.

"NEW CHEMICAL PRODUCT"

Officials of W. R. Grace & Co. express enthusiasm over the possibilities GREX offers the plastics industry, characterizing GREX as "plastic of tomorrow" and "new concept in plastics." According to Mr. T. T. Miller, Polymer President, "GREX differs from other plastics to such a degree, it merits being called a new chemical product."

Exceptional toughness and resistance to extremes of heat and cold are the outstanding property improvements to be found in GREX. Resistance to chemicals, impermeability to moisture vapor, good electrical characteristics, and rigidity are other property areas in which GREX excels. This new material can be injection molded, extruded, compression molded, blow molded, calendered, vacuum formed and foamed. It can be machined, punched, drilled, welded and heat sealed.

VERSATILITY CITED

What does this mean to the plastics industry? "GREX," explains Mr. Miller, "gives the fabricator a quality resin with outstanding versatility. GREX permits him to convert ideas for completely new plastic products into selling items. And by switching to GREX, he can upgrade his present plastic products.

The Polymer Chemicals Division laboratories at Clifton, N. J. include a full line of commercial size plastic fabrication equipment for development purposes. Here, a trained and seasoned technical staff works with Grace customers to learn what plastic products can be better-made with GREX, to uncover new uses for plastics, and to discover more efficient fabrication techniques. The Grace technical staff have also proved their ability to help a customer in his own plant.

OFFER MARKETING SUPPORT

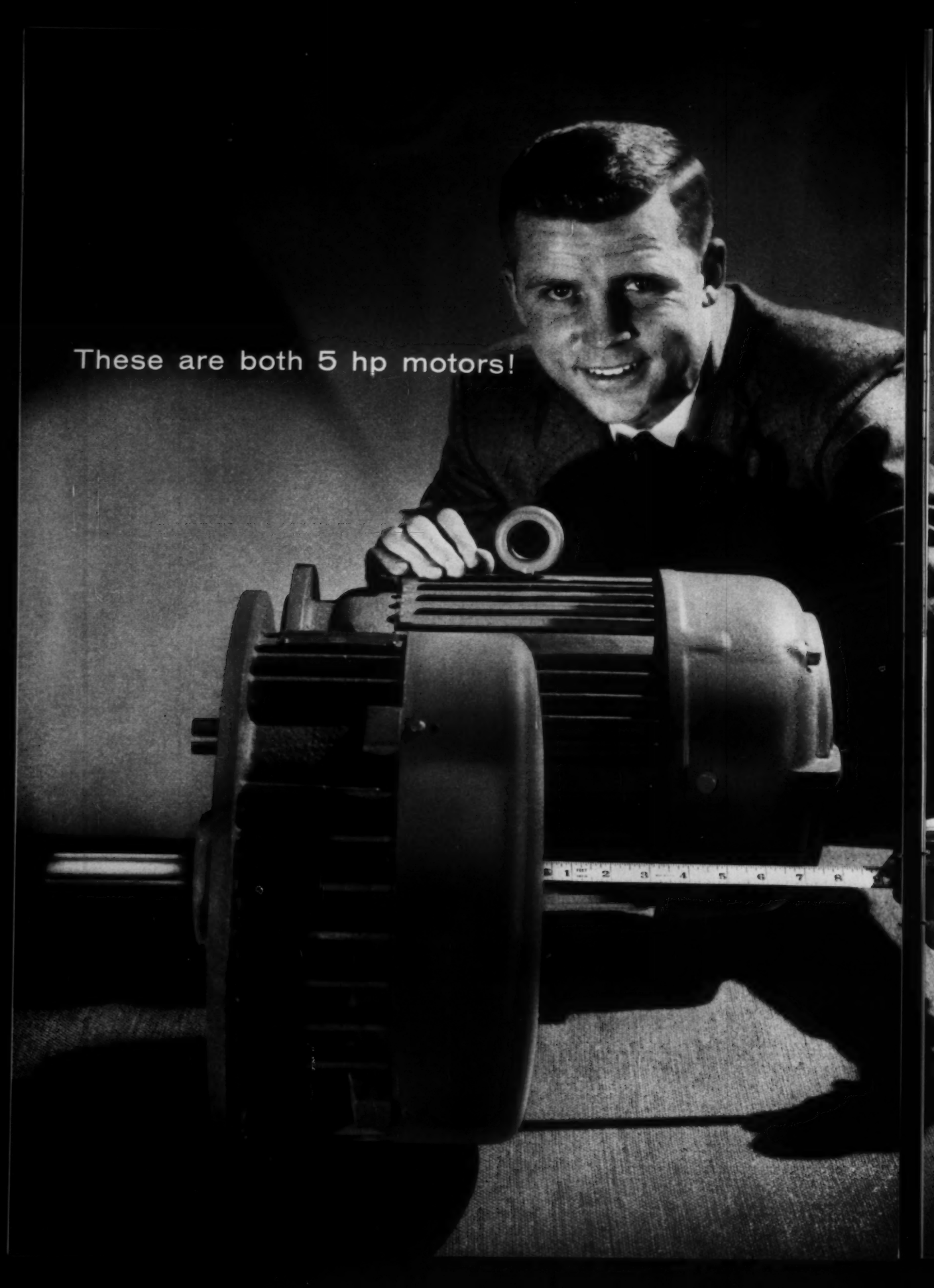
The makers of GREX extend this support to the marketing of GREX products as well. Grace merchandising experts will work with fabricators, and through them, with customers, to help search out their most promising markets. Then, Grace will collaborate on sales and promotion planning to achieve increased sales.

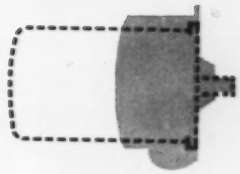
Mr. Miller emphasizes that GREX is expected to make substantial gains in markets now dominated by other materials like glass, wood, metal, offering the plastics industry unlimited potential. There is virtually no business that cannot put GREX to good use.

INQUIRIES INVITED

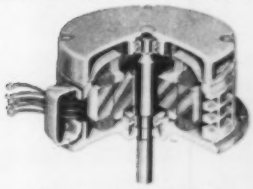
"GREX is a new product with great promise," he declares. "We believe in it to the tune of over $20 million. But more important, we at Grace are willing to work to prove out GREX in actual applications. Anyone interested in GREX has only to write or phone us at our Clifton offices—225 Allwood Road, Clifton, New Jersey, GRegory 2-6000. His inquiry will receive our immediate attention and he can be sure of full cooperation from our entire organization."

Circle 434 on Page 19


These are both 5 hp motors!



SAME NEMA RATING IN
60% LESS SPACE



PERFORMANCE-PROVED RADIAL
AIR-GAP DEPENDABILITY

New-product news from Louis Allis

60% shorter—
but with radial air-gap design!

New Louis Allis Pancake Motor preserves all the advantages of conventional motor construction

The new Louis Allis Pancake Motor is your solution to trouble-free power in any space-cramped motor application.

The Pancake is a remarkably short flange-mounted motor — up to 60% shorter and 33% lighter than standard motors of the same rating! And it is built in *conventional* radial air-gap design!

It's done by an ingenious forming process which literally compresses the end coils of a conventional radial air-gap motor into an exceptionally short length. The result is a compact, light motor ideally suited for horizontal or vertical mounting on machine tools, roof ventilating fans, or *any* close-quarter installation where space is a critical design factor.

What's more, this is achieved without sacrificing a single desirable characteristic: the stator still contains the same iron and copper as standard Louis Allis motors . . . standard NEMA service factor is maintained . . . high insulative values are retained by using proved Louis Allis varnishes and new insulating techniques . . . over-sized pre-lubricated bearings are used to guarantee long bearing life . . . and the entire motor is enclosed in an industrial-type cast-iron housing designed to shrug off abuse!

The housing and flange are cast in one piece: this permits extra-accurate internal machining which extends bearing life and reduces noise levels to a new low.

Investigate the Pancake Motor through your local Louis Allis District office. Sized from 1 to 15 hp, at 1800, 1200, and 900 rpm, in open drip-proof and enclosed non-ventilated or fan-cooled enclosures. Write for Bulletins 2100 and 2150 to the Louis Allis Co., 459 E. Stewart St., Milwaukee 1, Wisconsin.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

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How would YOU make a Pirn?

A large manufacturer of textile fibers uses this pirn in its textile yarn processing operations. It revolves at speeds up to 12,000 rpm so it must be accurately machined and balanced to withstand tremendous centrifugal forces. The pirn must be smooth on all surfaces and edges to prevent snagging and breaking yarn fibers. It must also be tough to resist razor-sharp knife edges when waste yarn is removed. Press fit assembly demands close tolerances.

Use Richardson Plastics!

For the barrel, Richardson INSUROK tube stock Grade T-617. Size: 1¾″ O.D. with 3/16″ walls. This is a paper base phenolic with excellent physical strength, low cold flow, stability in high humidity and surface finish hard enough to withstand razor-sharp knives. Machining tolerances: length ± .002″; diameter ± .0015″; inside diameter .002″.

The base and top of the pirn are molded from Richardson macerated plastic. Maceration lends greater strength, yet does not affect precision machining qualities. Machining tolerances: base flange diameter + .000″ −.010″; counterbore depth ± .0025″; counterbore width ± .0025″; top and base plug diameter ± .001″.

The flange near the top is made of INSUROK, nonwoven cotton mat base phenolic Grade T-836. It has great uniform mechanical strength and machines well with smooth surfaces. (T-836 is also excellent for gears and other parts requiring good mechanical strength in all directions.)

The pirn is press fit assembled with a special adhesive.

Richardson laminated tubes, rods, sheets, and molded plastics are being used successfully for many products or component applications, both mechanical and electrical. Learn more about Richardson plastics and engineering services. Write for the Laminate Catalog.

100 YEARS OF EXPERIENCE AND IMAGINATION 1858 1958

the RICHARDSON COMPANY

Founded 1858

RICHARDSON PLASTICS
LAMINATED and MOLDED

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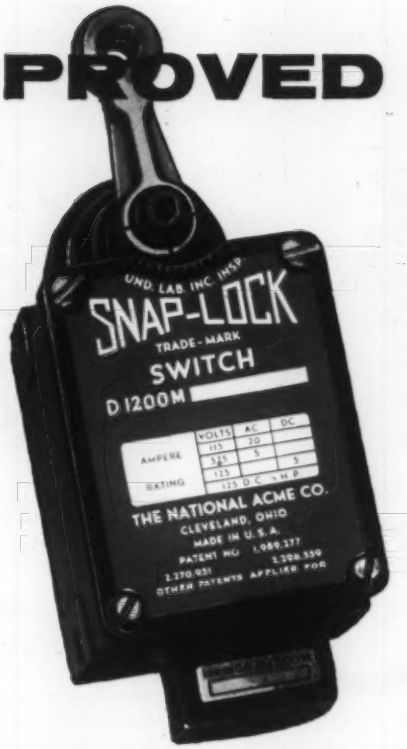
Circle 436 on Page 19

PROVED . . . by millions of contacts

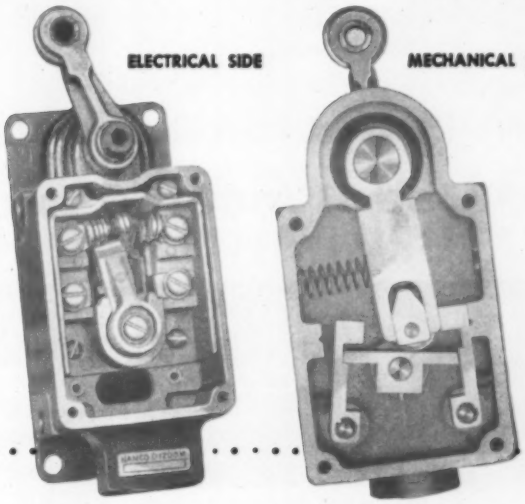


NATIONAL ACME
SNAP-LOCK
TRADE MARK

As illustrated below, National Acme SNAP-LOCK Limit Switches employ a basically simple yet positive *snap-action* locking mechanism—with extremely few moving parts. Thus wear is reduced to a minimum and dependable trouble-free service. far beyond normal limits, is assured.

The double-throw contact lever, connected directly by shaft with the latch bar, carries self-wiping coin silver contact points to assure quick action make or break—reducing wear ever further.

Electrical and mechanical sides are separated by a wall within a sturdy die-cast housing which is fully insulated and is dust and oil-tight.



THE ORIGINAL
SNAP-ACTION LOCKING SWITCH

SNAP-LOCK LIMIT SWITCHES. Made in single-pole and double-pole series, in four types: Standard, Short Travel, Neutral Position and Push Lever. With the exception of the Push Lever Switch, all are adaptable to special enclosures for hazardous location service and may be used with various styles of operating levers. For AC or DC service.

and now . . .

a new design concept for **CONTROL STATION SWITCHES**
the heavy-duty . . . oil, water, dust tight **GOLD-N-RING**
made by machine tool builders to machine tool specifications

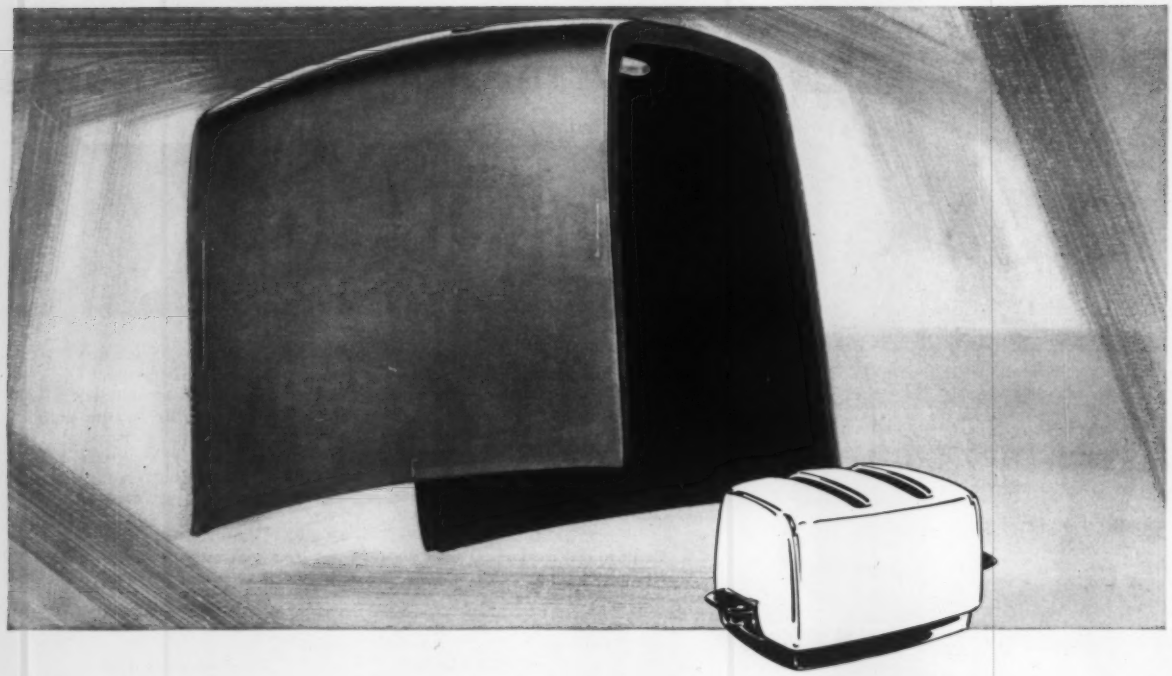
Heavy duty silver-alloy contact points provide maximum electrical capacity, long life.
Heavy duty terminal screws have ⅜" thread contact to prevent stripping during installation and permanently secure wires for continuous, trouble-free service.
Single or double-pole contact block assemblies—can be used interchangeably with several types of GOLD-N-RING push button and selector operator heads.
Rated for 600 volts—AC or DC. Meets all Joint Industry Committee and National Machine Tool Builder's Association requirements.
Protected against oil and water seepage in operator head by Sealtight oil-resistant rubber diaphragm.
Easily replaces existing switches.

ELECTRICAL MANUFACTURING DIVISION

the National Acme company

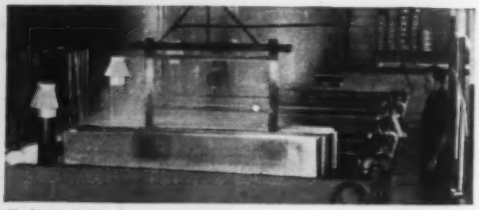
188 EAST 131st STREET, CLEVELAND 8, OHIO

Circle 437 on Page 19



Form flat-polished metal without marring! Use Bonderite and Bonderlube

Multiple head flat polishing at Production Finishing Corporation, Detroit.



Polished sheets are treated with Bonderite and Bonderlube before forming.

Bonderite and Bonderlube protect that smooth, flat-polished finish through forming and fabricating. Parts go direct to the plating bath from forming operations with only a light buffing.

All types of products are being made this way—automobile bumpers, automotive trim, toaster and small appliance bodies, home laundry equipment components and many other formed parts.

Cost reductions are big with Bonderite and Bonderlube: Polishing costs on bumpers went from 9c a square foot for contour polishing to 0.8c a square foot for flat polishing before forming. Savings of 10c to 30c a square foot have been reported by other industries.

The Parker technical representative has full information on this cost-cutting combination. A letter or phone call will bring it to you.

Since 1914— leader in the field

PARKER RUST PROOF COMPANY
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BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

*Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.

Circle 438 on Page 19

Circle 439 on Page 19→

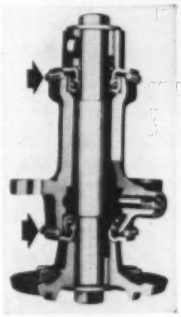
DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 47

Icing No Problem to Moving Joints Protected with Silastic "O" Rings

Neither sleet, snow, heavy icing conditions nor rain can hamper the reliable performance of outdoor transmission line switches manufactured by Line Material Industries. Reason: Moving joints are protected with Silastic*, the Dow Corning silicone rubber; bearings are lubricated with an all-weather Dow Corning silicone compound.



Location of Silastic "O" rings is shown in the photo. Slightly larger in diameter than the joint openings which they seal, the "O" rings project outward, thereby suspending in cantilever any ice that may form. Any movement of a joint "pops" the ice off!

The "O" rings are made of Silastic because it remains soft and flexible from —130 to 500 F, far beyond the limits of organic rubber seals. This temperature range is more than a match for the extremes to which the switches are exposed. (Cont. Pg. 2)

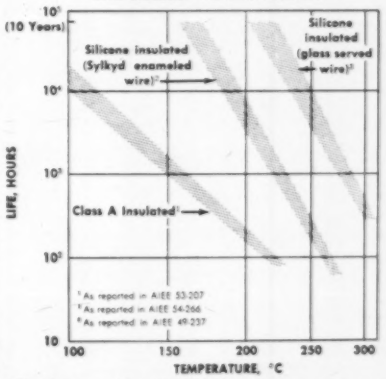
*T.M. REG. U.S. PAT. OFF.

50 TIMES MORE RELIABLE WITH SILICONE INSULATION

Increasing the reliability of magnetic brakes and couplings by insulating them with silicone dielectrics has paid handsome dividends to the Baylor Company, Houston. Result: greater customer satisfaction plus improved maintenance-free performance for their product.

Unconditionally guaranteed for a full year, Baylor Elmagco brakes and couplings are used in oil drilling to dissipate the tremendous energy developed while lowering drill strings. Three years ago Baylor started insulating this equipment with Dow Corning silicone insulation, without increasing their selling prices.

Life Expectancy of Class A and Silicone Insulated Motors



The heat-stable silicone insulation so drastically reduced Baylor's replacement costs during the one year warranty period that savings far exceeded the higher initial cost of using silicone insulation. Coil replacements dropped from 30% (Cont. Pg. 2)

MOTORS MADE MORE RELIABLE WITH SILICONE LUBRICANTS

A good example of the way Dow Corning silicone lubricants help designers assure maximum reliability and efficiency for tiny sensitive mechanisms is found in the new Synchron RPH timing motors developed by Hansen Manufacturing Co., Princeton, Indiana.

Like all Synchron timing motors, these units are only slightly larger than golf balls. Despite their small size, however, they frequently control complex processing operations where a slow-down or work stoppage would prove extremely costly.

Hansen engineers have found that one way to guard against failures in these midget mechanisms is to pack all brass and phenolic gears and steel pinions in the train, as well as the motor bearings, with a Dow Corning silicone lubricant.

Unaffected by aging or extreme temperature variations, the silicone lubricant enables these units to perform with maximum dependability and minimum maintenance. The silicone lubricant pays for itself, according to Hansen, by "eliminating leakers, withstanding high and low operating temperatures, and providing better storage life."

The new RPH timing motors operate at 600 rpm. Gear reductions of 1 to 45,000 are possible, giving output speeds as low as 0.8 rph. The housings are varnish-sealed — may be mounted in any position.

No. 476

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

NEW LITERATURE AND TECHNICAL DATA ON SILICONES

Silicones as Dielectrics. Just published. A 12 page, fact-filled must for design engineers. It's a convenient selection guide to the silicone dielectric most adaptable to particular applications that range from electronic components and assemblies to power distribution equipment and motors. *No. 480*

1958 Guide to Dow Corning Silicones—consists of 16 pages filled with data and illustrations suggesting ways in which you can cut costs, simplify designs, improve performance and add new sales appeal to your products with Dow Corning Silicones. Cross indexed for handy reference, this all-new Guide includes properties and uses for the silicone products developed in recent months. *No. 481*

Silicones in the B-58 is the subject of a recent article from AVIATION WEEK. It points up the wide-spread use of these new engineering materials to help military equipment meet more demanding performance requirements. Designers of industrial equipment also put the unusual properties of silicones to advantage. *No. 482*

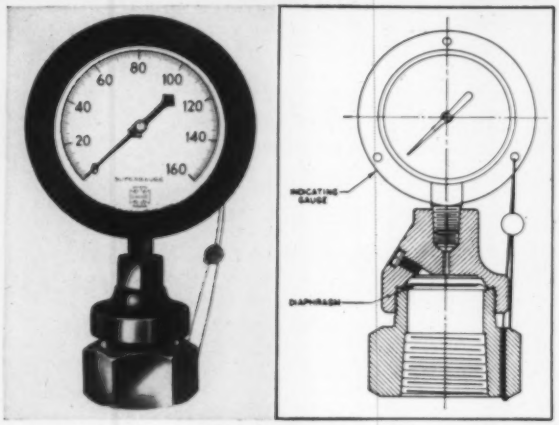
Antifoam B, the lowest priced silicone foam-killer, has greater stability than any other water dilutable silicone defoamer commercially available. Antifoam B will not separate, oil out, settle or precipitate in most applications; retains uniformity and effectiveness even under adverse storage or operating conditions. Ready to use, it requires no diluting or pre-mixing. *No. 483*

New Silicone Coating for paper and paperboard aids packagers and processors of sticky materials —it keeps gummy and tacky materials from sticking to all types of bags, boxes, innerliners, wrappings and interleaving sheets—it will not migrate nor contaminate goods in contact with it. Send for informative brochure containing sample papers. *No. 484*

Pressure-sensitive silicone tapes — that stick to wet or dry surfaces; form good bonds; have high dielectric strength; repel moisture; are not affected by corrosive chemicals—are described in a new folder designed to help you choose the tape best suited to your application. *No. 485*

SILICONE FLUID WIDENS PERFORMANCE RANGE

By hurdling the performance barriers imposed by organic fluids, Dow Corning Silicones improve the designs of many products where fluids are used as damping, coupling or springing media. This application from the United States Gauge, Sellersville, Pa. provides a good demontsration of the versatility and economy of silicone fluids.



These gauges are designed to measure the pressure of fluids too corrosive for ordinary pressure gauges. USG makes them corrosion-free by separating a metallic diaphragm from a Bourdon spring with chemically-inert Dow Corning 200 Fluid. The cost per unit for the silicone fluid—only 30 cents.

Compressing only 10.9% at 20,000 psi, the Dow Corning 200 Fluid transmits pressure instantly to assure quick, accurate readings. It does not corrode actuating elements. What's more, it makes the gauges operable over a far broader temperature span than possible with even the best organic fluids.

Engineers at United States Gauge cite these reasons for standardizing on Dow Corning silicone fluids for over seven years: "Silicone fluid is specified primarily because it is noncorrosive to the materials used, including the cold rolled steel sockets. Should the diaphragm be ruptured, the fluid will not cause dangerous chemical reactions to introduce toxic or taste materials to edible products. It has the low vapor pressure necessary to permit the evacuation incident to solid filling, and it will not absorb water to interfere with the evacuation process." *No. 477*

SILICONE INSULATION *(Cont.)*

of total output to a mere 0.55%, only one-fiftieth of the previous rate.

While the brakes are designed to dissipate energy up to 5000 hp, actual rates are frequently much higher. The silicone insulated brakes operate efficiently despite temporary overloads that would quickly burn out any other type of insulation.

Recently, for example, the cooling water supply failed while a brake was lowering 12,600 feet of pipe. Baylor engineers calculate this pipe actually developed 1,587,000,000 foot pounds of energy. The overheated brake reportedly glowed almost red hot. While the heat warped and ruined the rotor, the silicone insulated coils were undamaged and later tested out as good as new! *No. 478*

SILASTIC "O" RINGS *(Cont.)*

"All-weather" considerations also prompted L-M to specify Dow Corning 11 Compound as the lubricant for the joints and bearings of these switches. In their words, "These switches are often located in industrial areas where dilute acids and alkalis are found in the atmosphere. However, this presents no problem for Dow Corning 11 Compound since it is unaffected by these agents. In addition, Dow Corning 11 is nongumming, nonmelting, noncorrosive, and water repellent assuring the switches years of trouble-free operation. *No. 479*

Dow Corning Corporation, Dept. 682, Midland, Michigan

Please send me: 476 477 478 479 480 481 482 483 484 485

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TITLE _____

COMPANY _____

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CITY _____ ZONE ____ STATE _____

SILICONE NEWS is published for product design and development engineers by

first in silicones

Dow Corning CORPORATION
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Circle 440 on Page 19

"Automation has raised our productivity to new high levels,"

reports a paper maker

Paper stock is automatically moved from this operation to the next by Jeffrey spiral conveyors.

JEFFREY
Spiral Conveyors

are a part of their automatically-controlled materials handling

• The high degree of automation recently introduced here has raised productivity per man to new high levels. Transfer of materials in process is largely under automatic control, for example, as evidenced by these Jeffrey spiral conveyor systems.

Jeffrey spiral conveyors offer an economical means of handling dry, loose bulk materials. Compact, they occupy a minimum of space. Convenient, they can be fed or discharged at any point along their length. Jeffrey makes them in open and dust-tight styles, of metals to suit particular requirements.

When adapting spiral conveyors to your products, ask Jeffrey engineers for their recommendations and assistance. Catalog 851 describes the various types available to you. The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

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...THEN WE'D BETTER ORDER INTERNATIONAL!
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B.Y. JONES PURCHASING

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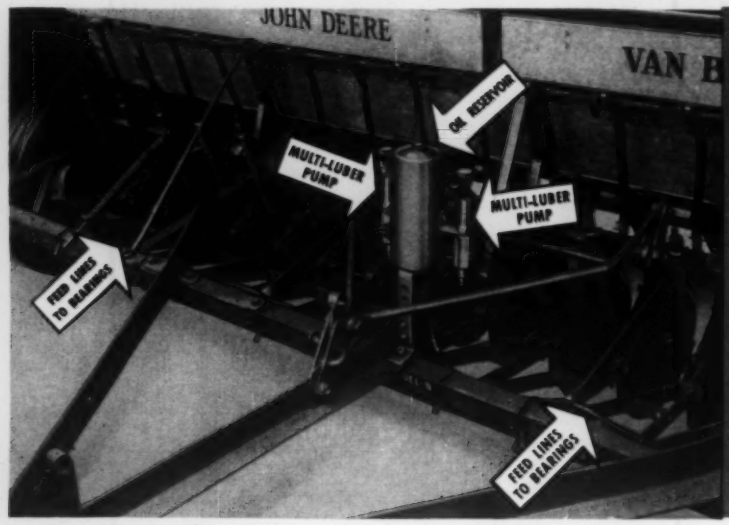
Circle 442 on Page 19

lubri-facts from Lincoln

No. 101 of a series of case histories on the vital role of lubricant application systems in engineering design.

DESIGN ENGINEERS IN EVERY FIELD ARE FINDING PROFITABLE NEW APPLICATIONS FOR LOW-COST *Lincoln* Power Lubrication Systems

- **Assure positive pressure lubrication to all bearings, simultaneously**
- **Increase machine efficiency in the plant, on the road, in the field**
- **Pay for themselves in lower operating costs—longer machine life**



Case History:

JOHN DEERE VAN BRUNT CO.

Disk bearing life for John Deere Van Brunt Company Grain Drills is infinitely prolonged through metered positive pressure lubrication to each bearing. Lincoln Multi-Luber® Systems save labor by eliminating need for individual lubrication of furrow openers... save time and trouble by using same oil as used in the tractor crankcase.

John Deere Van Brunt Company is one example of how progressive manufacturers in every field add more sales power to their products... by finding unlimited applications for versatile, low-cost Lincoln Multi-Luber Power Lubrication Systems. This tested method of lubricant application permits simultaneous lubrication of all bearings in seconds... on farm implements, or on *any* machinery or equipment having multiple bearing points. Provides proper, frequent lubrication... flushes bearings as it lubricates... extends bearing life and eliminates costly lubrication downtime. Easy to use... simple to install... precision-built to last.

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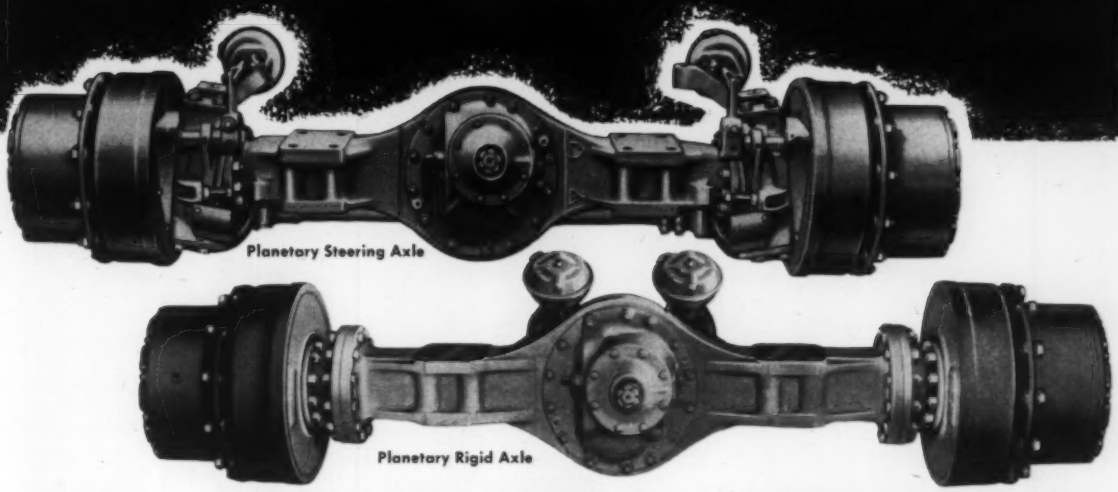

Planetary Steering Axle

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steering and rigid, from 20,000 to 75,000 lb. capacities!

A complete range of new, heavy-duty planetary axles—with a steering axle operationally matched to each rigid axle in the line—is now included in the Timken-Detroit family of advanced design axles. This matching of steering and rigid units brings you just the right axles for every requirement in both special off-the-road equipment and heavy-duty trucks.

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ROCKWELL SPRING AND AXLE COMPANY
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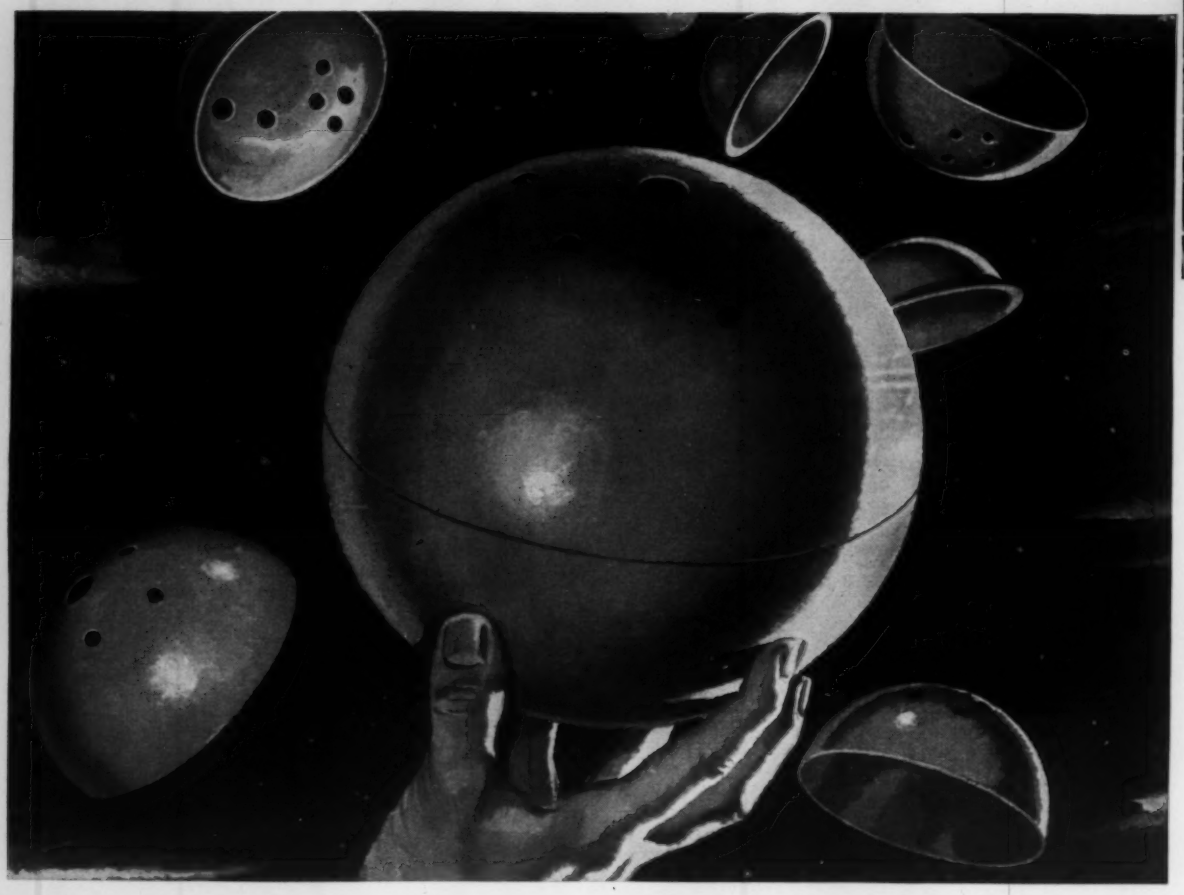
SAVE WEIGHT, FIGHT CORROSION, ADD STRENGTH AND TOUGHNESS



TITANIUM HEMISPHERES ARE STRONG, LIGHTWEIGHT, DEFY CORROSION BELOW —150°C. They are used in highly specialized aeronautical applications calling for high strength, light weight, and resistance to the severe corrosive action of liquefied gases at severe sub-zero temperatures.

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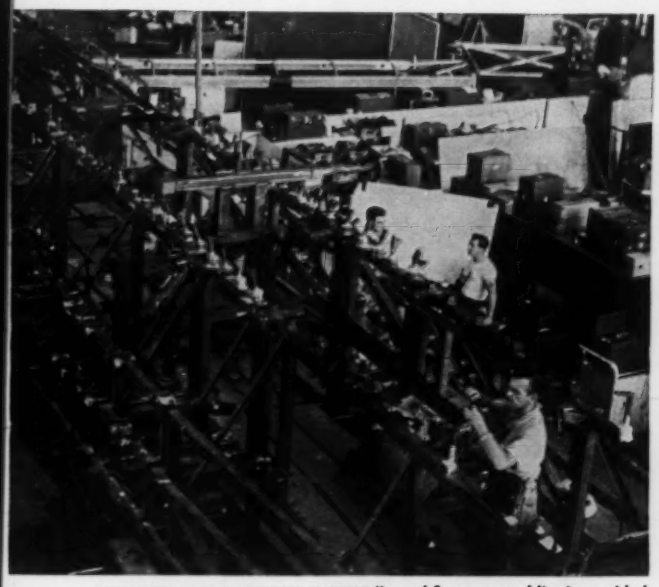
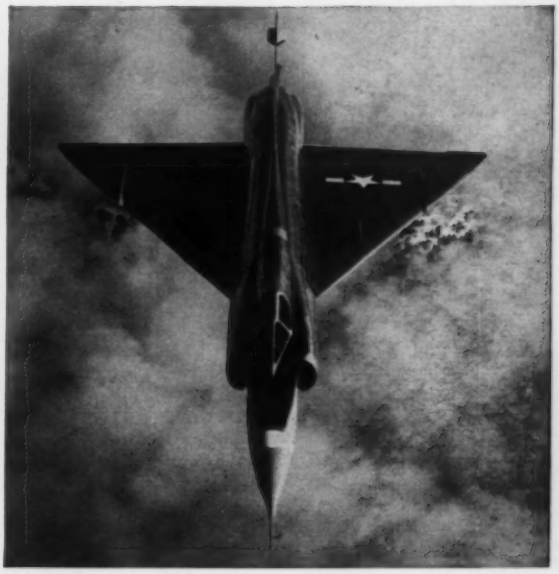
1. Titanium reduces weight without sacrifice of strength or safety. In fact, titanium offers the highest strength-to-weight ratio of construction materials.
2. This exceptionally high-strength property enables this product to withstand burst pressures in excess of 2,000 lbs. psi.
3. Titanium's extremely high corrosion-resistant properties defy the corrosive action to which the units are constantly exposed.

The entire fabricating operation is performed without difficulty and with little change in procedure as compared to other materials. Fabricating steps include drawing, trimming, piercing, extruding, and welding.

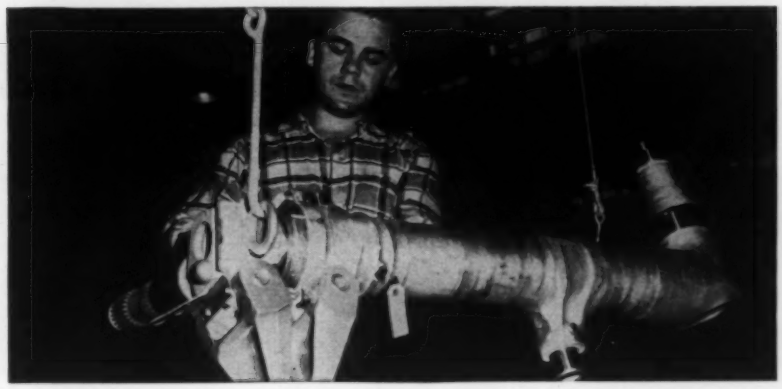
Does this application of Republic Titanium generate an idea for your product that needs to be strong, lightweight and corrosion-resistant? Republic Metallurgists are ready to help you apply titanium's advantages now. This service is confidential and without obligation. Mail coupon today for more information.



STRENGTH AND SAFETY IN MISSILE jig and fixture assemblies is provided by 4" x 4" square carbon steel mechanical tubing. It is used because of its greater strength-to-weight ratio in structural applications. Elimination of accident-causing sharp edges adds to the safety margin. Republic Steel and Tubes Engineers will help you design ELECTRUNITE Mechanical Tubing into your product to speed production, cut costs, save weight, improve product performance. Mail coupon.



TOUGHNESS, HIGH STRENGTH-TO-WEIGHT RATIO, resistance to heat and corrosion are advantages of ENDURO Stainless Steel designed into both structural and operating parts of supersonic Convair F-102A. ENDURO is made for flight in both military and civilian aircraft. Its outstanding combination of properties offers almost unlimited freedom in design and application. Republic will help you apply it to best advantage. Write us.



MAXIMUM RESISTANCE TO FATIGUE, strength and toughness are provided by Republic Alloy Steel in landing-gear struts of North American's F-100. The struts are made by Bendix Aviation Corporation. Bendix and Republic metallurgists, working closely with North American engineers, developed a new grade of alloy steel to meet exacting requirements of the strut's inner and outer cylinders. It has a strength range of 220,000—240,000 psi and maintains this great strength at wide temperature extremes. Republic Alloy Metallurgists are available to help with your projects.

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Company _____

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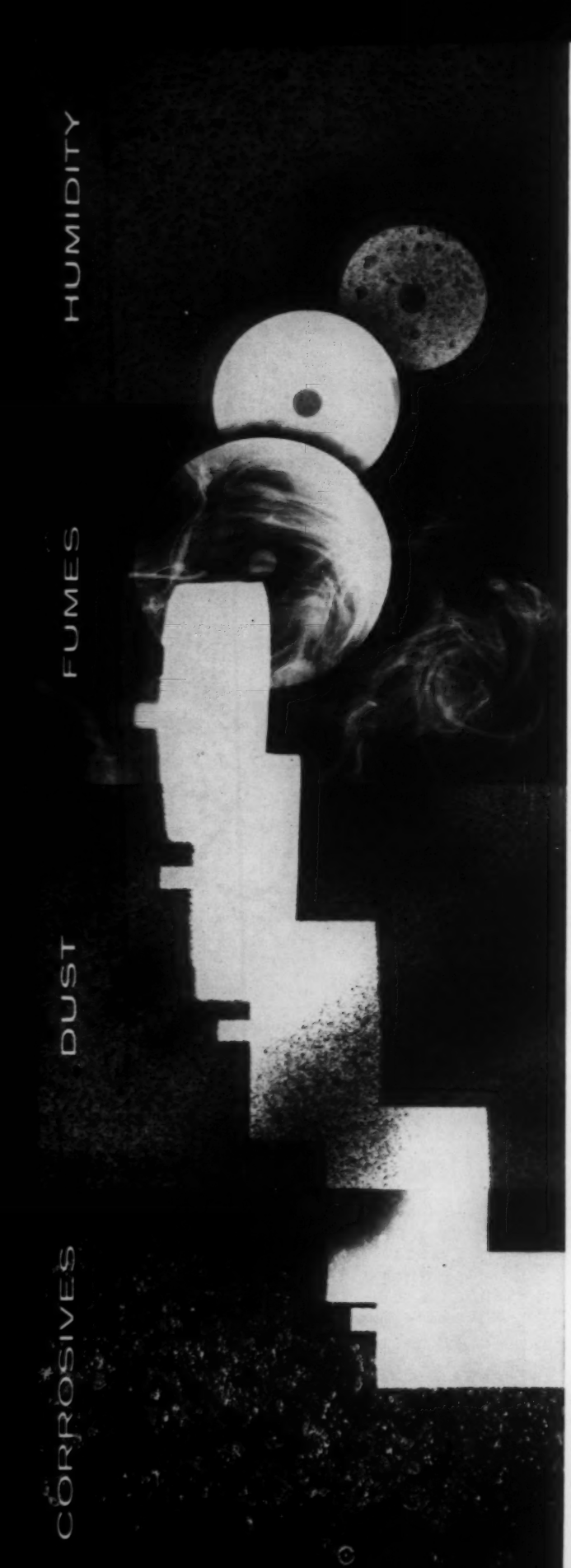

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Customizing electric motors to meet the specific requirements of original equipment manufacturers is *our business*. Because we're organized that way, costs are reasonable.

In addition to customizing for environment, we can increase torque, stretch a motor tall, squat it flat, or design-in special ambient temperature rating. We'll make a motor cool, flush, submersible, or give it a special finish. *You name it!*

So go ahead freely! Design your product to do its job. We'll fit a motor to it that will make your product perform the way you want it to . . . look as good as it should . . . last as long as you say it will . . . and sell faster because of it.

FREE! Write for this 24-page booklet. It explains when to specify *Customized* motors, shows examples of design variations, illustrates case histories of *Customized* motors for actual products. Write: Jack & Heintz, Inc., 17626 Broadway, Cleveland 1, Ohio.

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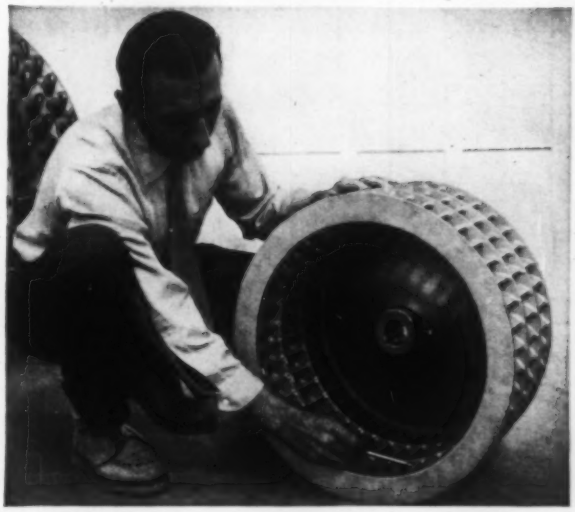
Circle 446 on Page 19

HAYNES Alloys solve the *tough* heat problems

10 YEARS' SERVICE at 1600 to 1800 deg. F.

Fans with impellers or rotors made of MULTIMET alloy circulate the atmosphere inside heat-treating furnaces and are exposed to temperatures from 1600 to 1800 deg. F. They withstand both reducing and oxidizing conditions produced during cyaniding, annealing, and nitriding operations. Their average life is about 10 years.

MULTIMET is one of 12 HAYNES alloys specifically designed for use where strength at high temperatures is essential. For details on properties, forms, and prices send for descriptive literature or contact our nearest sales office. HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana. Sales Offices in Chicago, Cleveland, Detroit, Houston, Los Angeles, New York, San Francisco.



Designed to operate at 1800 deg. F., this impeller has 180 blades formed from MULTIMET alloy sheet. Impellers range from 12 to 48 inches in diameter. Furnace rotors, cast of MULTIMET alloy, operate at temperatures up to 2100 deg. F.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

Kokomo, Indiana

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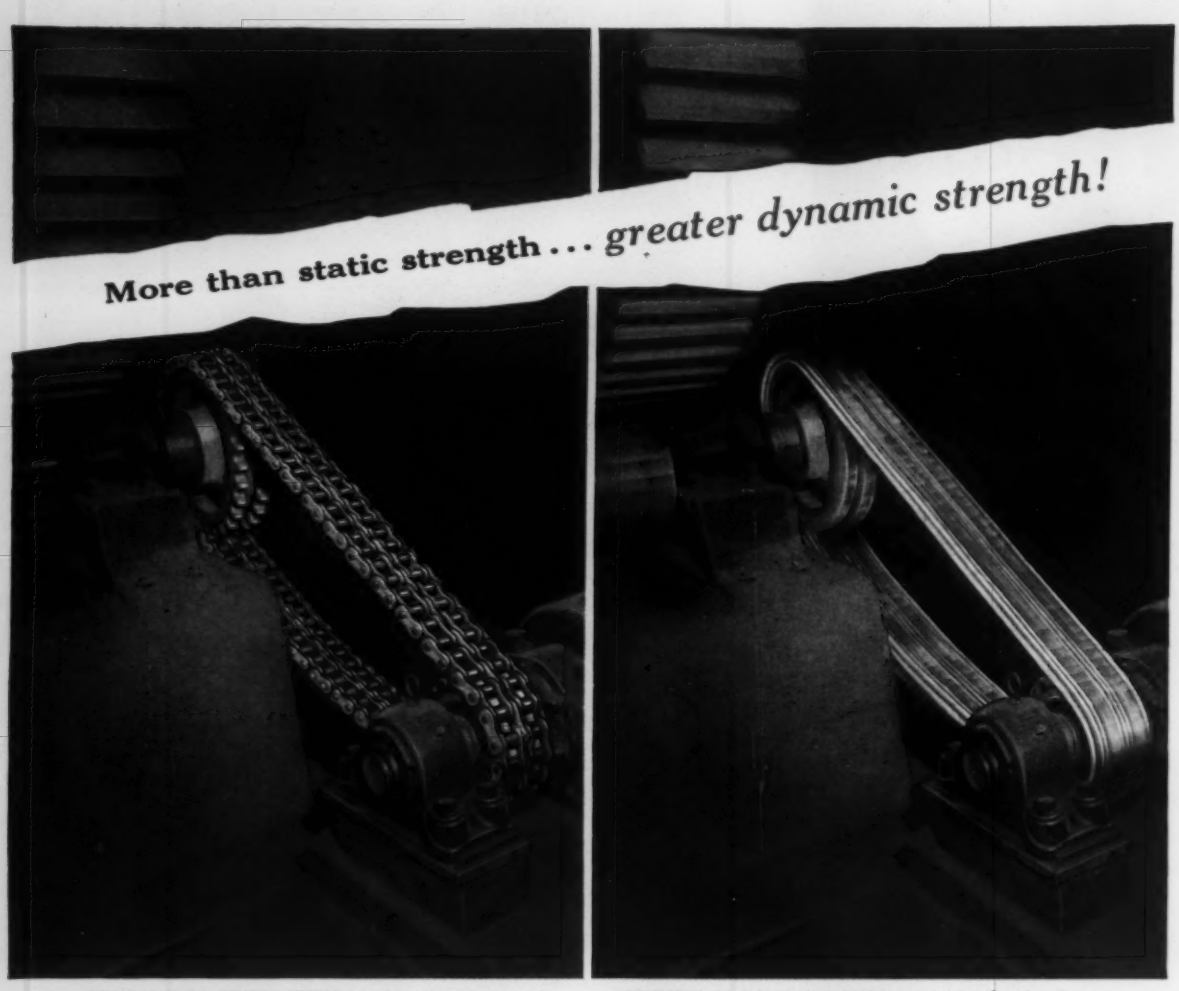
"Haynes," "Multimet" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.



RESISTANCE TO TENSILE STRESS is achieved with properly heat-treated, accurately machined side bars made of premium steel and fitted with properly hardened pins, bushings, rollers.

STRENGTH OF CHAIN IN MOTION results from such refinements as pitch-hole preparation, micro-finish of parts, special processing of side bars, pre-lubrication, rigid quality control from materials selection to final boxing.

Big reason for the extra life from LINK-BELT roller chain

STARTING shock, heavy loads and impact of sprocket engagement on modern heavy-duty machinery requires a chain that will resist fatigue. That's why Link-Belt gives you *greater dynamic strength* to shrug off stresses. Pre-stressing, closer heat-treat control, lock-type bushings, shot-peened rollers—all these Link-Belt refinements contribute extra stamina for extra life . . . provide smoother, more efficient chain performance . . . reduce drive and conveying costs.

You have a choice of single- or double-pitch, single- or multiple-width chain. Get in touch with your nearby Link-Belt office for further information.

LINK-BELT

ROLLER CHAIN & SPROCKETS

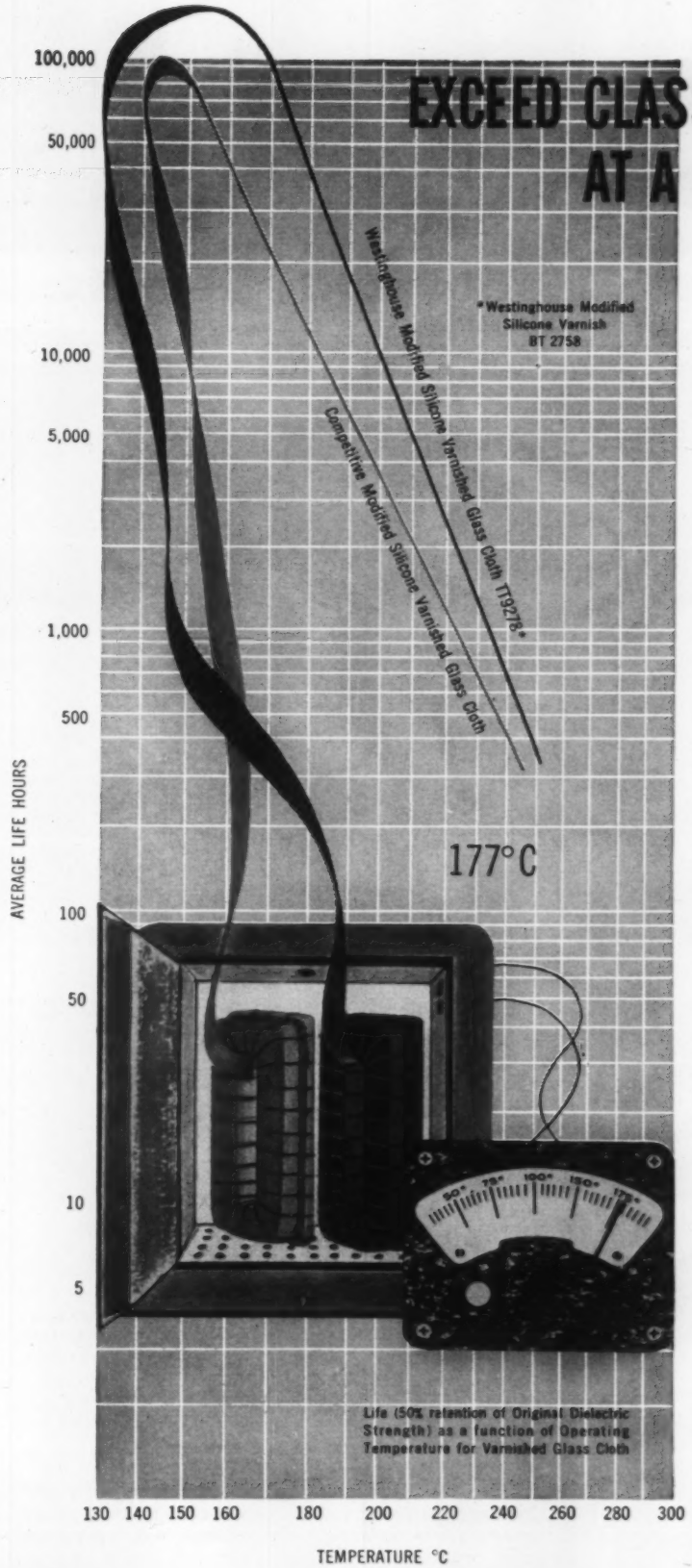
14,844-A

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

EXCEED CLASS "F"† PERFORMANCE AT A CLASS "B" PRICE

with

Westinghouse Modified Silicone Varnished Glass Cloth and Tape!



Like to *upgrade your product at no extra cost?*

You can! Your equipment will operate *better, longer* with an amazing new Westinghouse insulation—Modified Silicone-Resin-Treated Varnished Glass Cloth and Tape, Grade TT-9278! "9278" withstands temperatures up to 177°C for ten years! It'll hold up even under conditions of continuous overload!

That's not all—Westinghouse TT-9278's *oil and solvent resistance* far surpasses that of conventional Class "H" materials. Heated in oil or immersed in toluene for 48 hours, there's no evidence of disintegration. This new Westinghouse insulation approaches Class "H" Performance . . . at a Class "B" price.

"TT-9278" is only one of a Leadership Line of some 100 different Westinghouse tape and sheet insulation materials, designed to meet every Class "A," "B," "F" or "H" electrical insulating need.

There's a companion line of Benolite varnishes, finishes and enamels, too—for example, Modified Silicone Varnish BT-2758, used in producing "9278." Why not write for your free copy of the 8-page Westinghouse *Leadership Line Catalog?* Just fill out and mail the coupon below . . . we'll do the rest. J-06636

†New AIEE classification established June 21st, 1957, with a hotspot limit of 155°C.

YOU CAN BE SURE... IF IT'S

Westinghouse

Westinghouse Electric Corporation 1-10-57
Micarta Division, Trafford, Pa.

Please send me your Leadership Line Catalog on Westinghouse insulation, tapes, varnishes, finishes and enamels, B-7206.

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T-J spacemaker cylinder

Quality Engineered

to give quality results

with Extras . . . at No Extra Cost!

You get more—much more—when you specify and use any of T-J's complete line of Spacemaker cylinders. The Spacemaker is engineered to give you better, more accurate, and longer service—offers, exclusively, many extras . . . that are STANDARD, AT NO EXTRA COST!

Designed to eliminate tie-rods, providing greater strength . . . saves space . . . reduces manhours and costs in all push-pull-lift operations. OFF SHELF DELIVERY in a wide range of styles and capacities, with 64,000 combinations. Write for catalog SM 56-2 with complete engineering details. The Tomkins-Johnson Co., Jackson, Mich.

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RIVETORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

METAL PISTON ROD SCRAPER . . . Standard at No Extra Cost!

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STREAMLINED DESIGN . . . Oil Pressure to 750 P.S.I.—air to 200 P.S.I. Standard at No Extra Cost!

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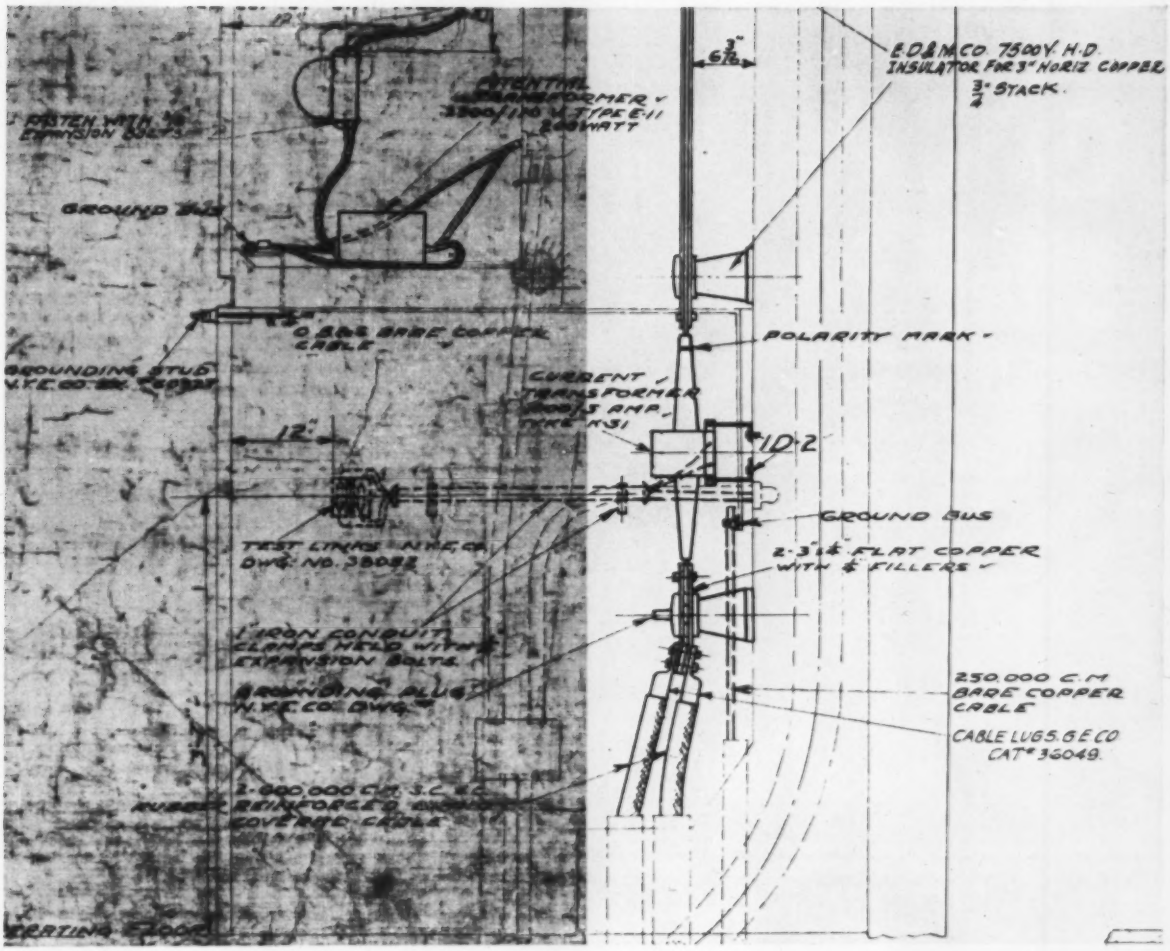

How to get better copies of your drawings

Here are two white prints spliced together for your comparison. The copy on the left was made from a sensitized cloth intermediate. This intermediate, and the print produced from it, bear the same scars of age and wear as the old original drawing.

To make the copy on the right, the worn original was reproduced on CRONAFLEX, Du Pont's amazing new engineering reproduction film. See how the CRONAFLEX intermediate has eliminated the kink marks, cleaned up the smudging, actually improved the drawing.

CRONAFLEX improves the copies of your drawings for several reasons. First, the physical characteristics of the films eliminate the kink and smudge marks from the prints. Second, the high contrast of CRONAFLEX gives you better intermediates, which means more legible blue or white prints. Third, because of the unexcelled matte surface of CRONAFLEX, you can do additional drafting or make corrections on "second originals" quickly, easily, and accurately.

CRONAFLEX engineering reproduction films are extremely versatile. They are available in three types: Direct Positive, Contact and Projection. All CRONAFLEX films are on Cronar® base, assuring unbelievable ruggedness, high dimensional stability, minimum moisture absorption.

CRONAFLEX will not tear, kink, shatter or become brittle with age or handling. CRONAFLEX has a matte finish that provides the finest pencil or ink acceptance. Lines do not smudge. Reproductions are cleaner, sharper, more legible.

Shouldn't you specify CRONAFLEX for your intermediates and "second originals"?

FOR MORE INFORMATION on CRONAFLEX, write to: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada (1956) Limited, Toronto.

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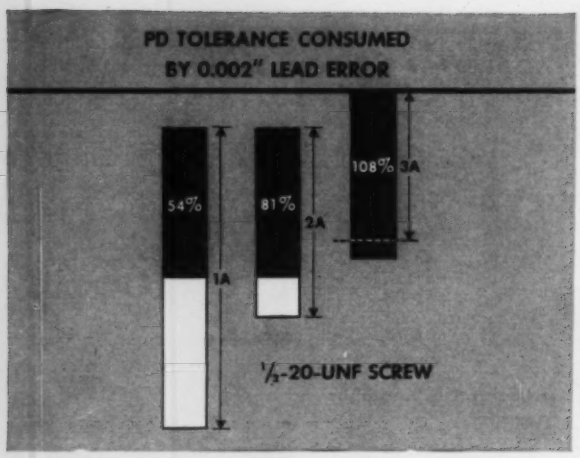

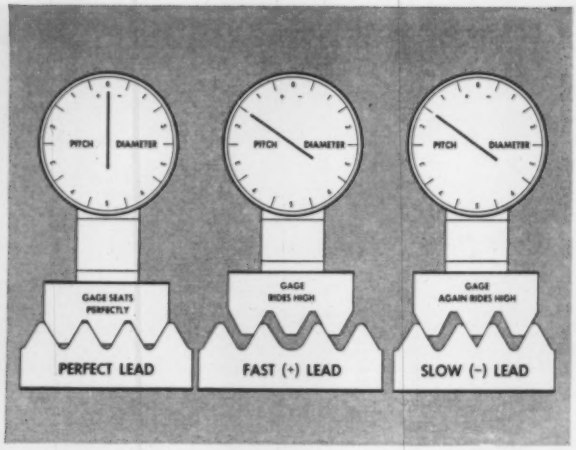

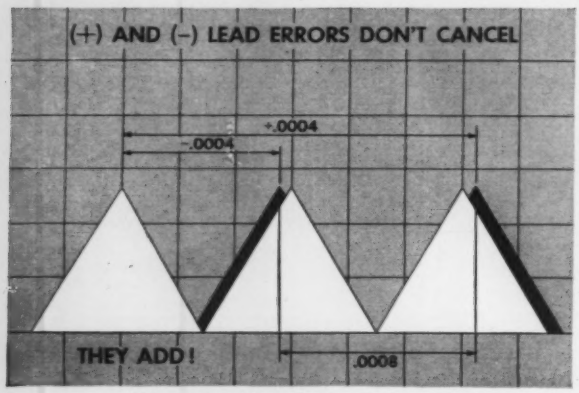

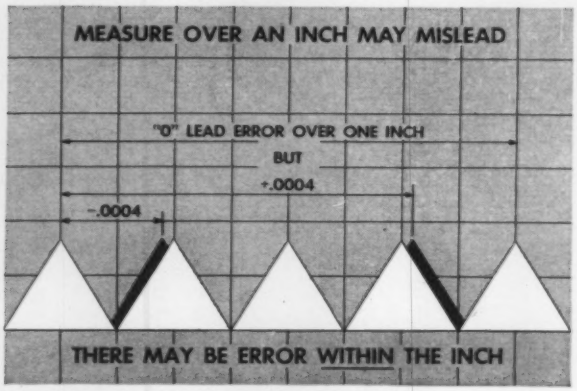

Typical illustrations from new SPS booklet show effect of lead error on PD tolerance, explain why plus and minus errors do not cancel and why lead error is not necessarily progressive.

Lead error: what it is; how to detect it — new SPS booklet tells all

A lead error of only .002 in. within length of thread engagement increases the effective diameter of a Class 3A ½-20 screw so that it will not go into its tapped hole. Smaller errors in lead—say .001 or .0005—can play equal havoc with the smaller diameter screw threads. Lead error accounts for over 50% of today's thread assembly problems, causing rejects, production delays, and excessive wear on power wrenching tools.

SPS has prepared a new booklet on this important but little-understood subject that should be helpful to anyone making, buying or using threaded fasteners. It explains the anatomy of lead error, its mathematics, its common causes, and the means for detecting and preventing it. Exposed are such fallacies as the theory that plus and minus lead errors cancel (they add) or that most lead error is progressive (it's mainly erratic).

All SPS UNBRAKO socket screw products are made to a true Class 3A fit with precisely controlled lead. Complete stocks are carried by industrial distributors. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

Form 2294: "A New Look at Lead Error—Thread Tolerance Thief No. 1." 16 pages with many illustrations. Write for free copy today.

We also manufacture precision titanium fasteners—write for free booklet

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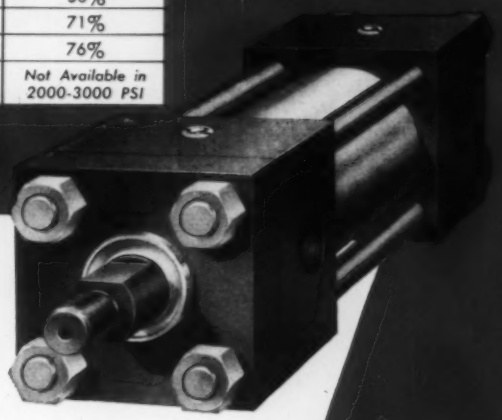
"JOB RATED"

HYDRAULIC CYLINDER LINE

JOB RATED, MODEL "LH"

BORE	CONTINUOUS SERVICE RATING	INTERMITTENT SERVICE RATING	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*



with IDENTICAL seals, design, and safety factors as the famous Miller "Power-Packed" Model "H" Line for 3000-5000 psi service.

ALL TEFLON* SEALED AGAINST EXTERNAL OIL LEAKAGE

SHEF SEAL
At Tubing Ends

Has zero axial clearance, metal backup, no "blind assembly." Teflon sealing strip of one cross-section dimension for all cylinder sizes—supplied on convenient spools.

Shear-proof
Heat-proof
Extrusion-proof
Fluid-proof

Piston Rod Flange Seal

Self-regulating, wear-compensating piston rod flange seal is pressure-energized, guaranteed leak-proof and never requires adjustment.

Teflon rod wiper keeps dirt out. Teflon hydraulic wiper keeps lubricant in.

Teflon sealing strip for bushing is one cross-section dimension for all cylinder sizes — supplied on convenient spools.

LOCK-SEAL
Cushion Adjusting Screw

Non-protruding screw automatically sealed and locked by Teflon ring. Interchangeable with ball check assembly for easy access.

CASE-HARDENED CHROME-PLATED PISTON RODS

Heat treated, stress relieved, high tensile steel piston rods, case-hardened, then hard chrome-plated.

NOW!... You can save MORE with quality Miller "Job-Rated" Cylinders than with cut-price, lesser quality hydraulic cylinders. And the "Job-Rated" Cylinders are also available under the same immediate shipment program (2 hours if necessary—3 days normal) as the Power-Packed Line.

*du Pont trademark for its tetrafluoroethylene resin

OTHER MILLER QUALITY FEATURES

- Rust-Resistant Surfaces
- Interchangeable, Space-Saving Square, 4-Tie-Rod Design
- Air Bleed In Cylinder Head
- Precision Honed Barrels

Circle 453 on Page 19

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DIVISION OF FLICK-REEDY CORPORATION

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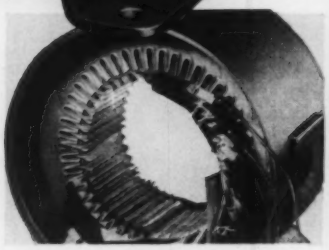
COUNTERBALANCE CYLINDERS • BOOSTERS

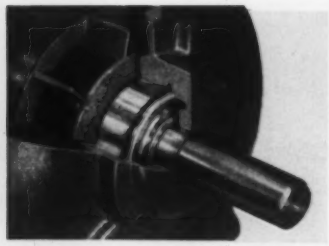
Udylite's

Robbins & Myers
build motors from
1/200 to 200 horsepower



MYLAR* INSULATION INCREASES MOTOR LIFE . . . insures positive insulation. Rag paper backing provides cushioning effect against abrasions and punctures. Entire motor winding is pre-heated, twice dipped in varnish and baked after each dip.

*DuPont registered trademark



BEARINGS POSITIVELY SEALED . . . Double row width ball bearings, sealed on both sides, eliminate frequent re-lubrication. Grease sealed in extra-large reservoirs, resists dust, temperature, humidity and high operating speeds.

"shining example" shows how...

R&M TOTALLY ENCLOSED FAN COOLED MOTORS BEAT CORROSIVE ATMOSPHERES

Udylite Corporation's famed Automatic Plating Machines put a shine on everything from sewing machine parts to automobile bumpers. R&M Totally Enclosed Fan Cooled Motors power the hydraulic system of these precision machines quietly, smoothly and without vibration. But most important they successfully combat the severe corrosive atmosphere common to all plating operations. R&M Motors are completely protected against this serious motor menace.

Complete R&M motor protection includes careful dipping, baking and painting of all steel parts . . . spraying of rotor and shaft with special rust-inhibitor . . . application of anti-corrosion primer to cast-iron end-heads and terminal box. A cast aluminum fan provides effective cooling by forcing air between enclosed internal and open external shells over motor's entire length. Other important features contributing to long-life protection and vigorous performance are described at left, below.

Robbins & Myers Totally Enclosed Motors range from ½ to 125 hp. Write today for Bulletin 500 MD

OPEN PROTECTED MOTORS . . .
R&M open protected motors to 200 horsepower are suitable for many applications formerly requiring totally enclosed construction. Investigate this economical possibility for your application. Write for free Bulletin 520.

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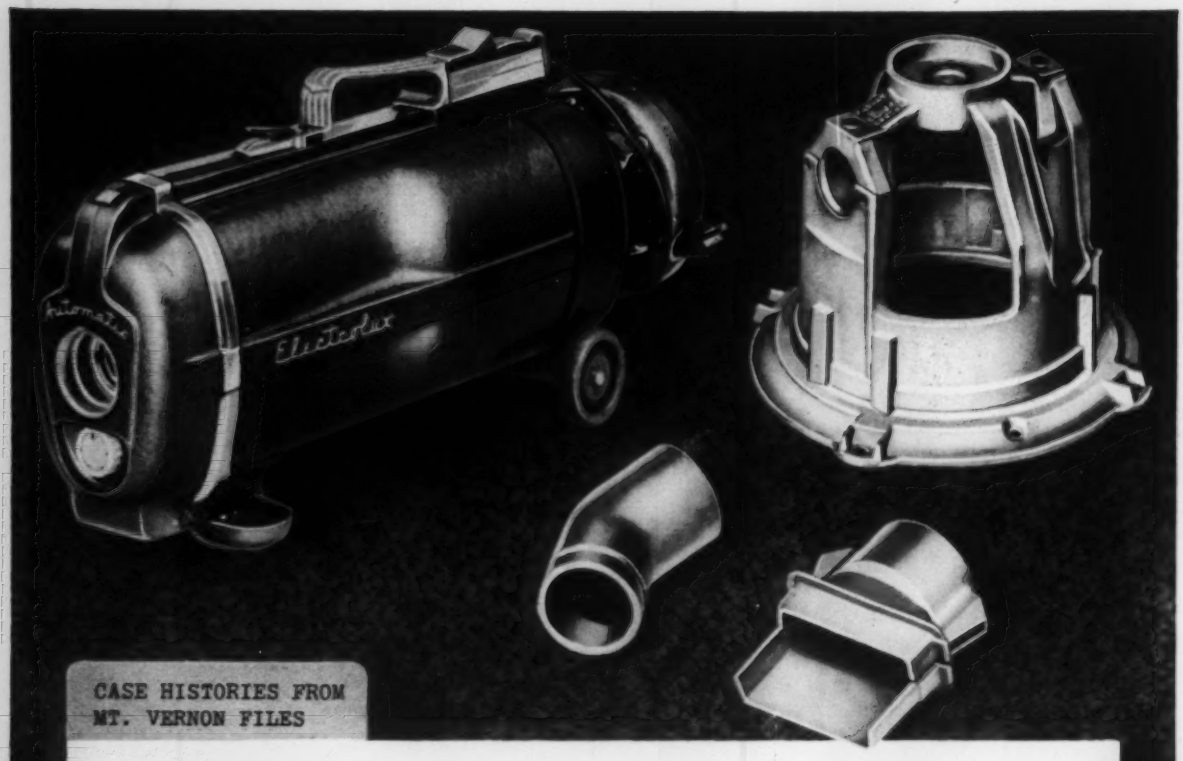

CASE HISTORIES FROM MT. VERNON FILES

"Brain" stops new Electrolux automatically!

The minute this new Automatic Electrolux Cleaner has absorbed so much dirt it can no longer operate at high efficiency, it stops and the cover pops open. Replacing the sealed paper dust bag with a new one sets it up for further operation. It is one of several exclusive Electrolux features which includes 20% greater suction power than any machine the company has ever made. This is due in part to the increased speed and power of its electric motor.

The additional power and the automatic features of this new cleaner were not, however, achieved at the expense of added weight, because it is remarkably light for an appliance of such power and flexibility. By using die castings for the motor frame, elbow and adapter, both weight and manufacturing costs were kept down. As you can see these parts are complex. The motor frame alone, for example, involves apertures of various sizes and shapes, lugs, curved members, straight members, flanges, fillets, vanes and shoulders all combined into a very lightweight yet extremely rigid, strong unit. The other parts, although smaller, are also "toughies". But die casting is the most economical method of producing these intricate parts which combine strength with light weight and holding to such close tolerances that little or no machining is reqiured to finish them.

Mt. Vernon can help you make the most of these and other die casting advantages by a complete four-fold service of: (a) consultation—to help with design and production problems; (b) die making—on modern tool and die equipment handled by skilled personnel; (c) castings—aluminum and zinc, guaranteed "on grade" at all times; (d) machining facilities—for handling any machining operations your castings may require. As in the case of Electrolux, a switch to die castings may profit you tremendously. Let's talk it over.

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DIE CASTING CORP.
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PHOTOGRAPHED ACTUAL SIZE
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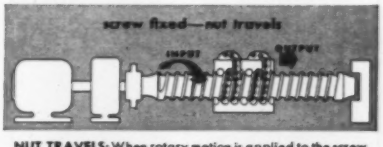
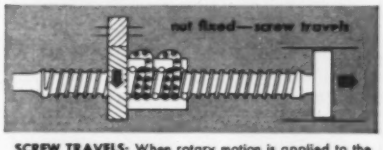


NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque than acme screws.



SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with unprecedented efficiency.

An unprecedented achievement in minimum size and weight—maximum efficiency, dependability and service life for ultra-precise controls.

It's another first from Saginaw—and the possibilities it opens up for improved electrical and electronic controls are limited only by your imagination! Radar tuners, missile and rocket guidance and telemetering systems, automatic switchgear, electronic machinery controls are just a few of the applications where this new miniature Saginaw b/b Screw will solve critical positioning/control problems. *It's so compact and light,* you can save substantially on space and weight. *It's so efficient,* (over 90%) you can use much smaller motors and gear boxes. *It's so precise,* you can position components within .0005 inch per inch of travel. *It's so dependable,* you can rely on remarkably long service life even in adverse environments.

You will find our 1958 Engineering Data Book extremely helpful in planning applications, or experienced Saginaw engineers will gladly make specific recommendations without obligation. Just phone, write or mail the handy coupon.

Saginaw

ball bearing Screw

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WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

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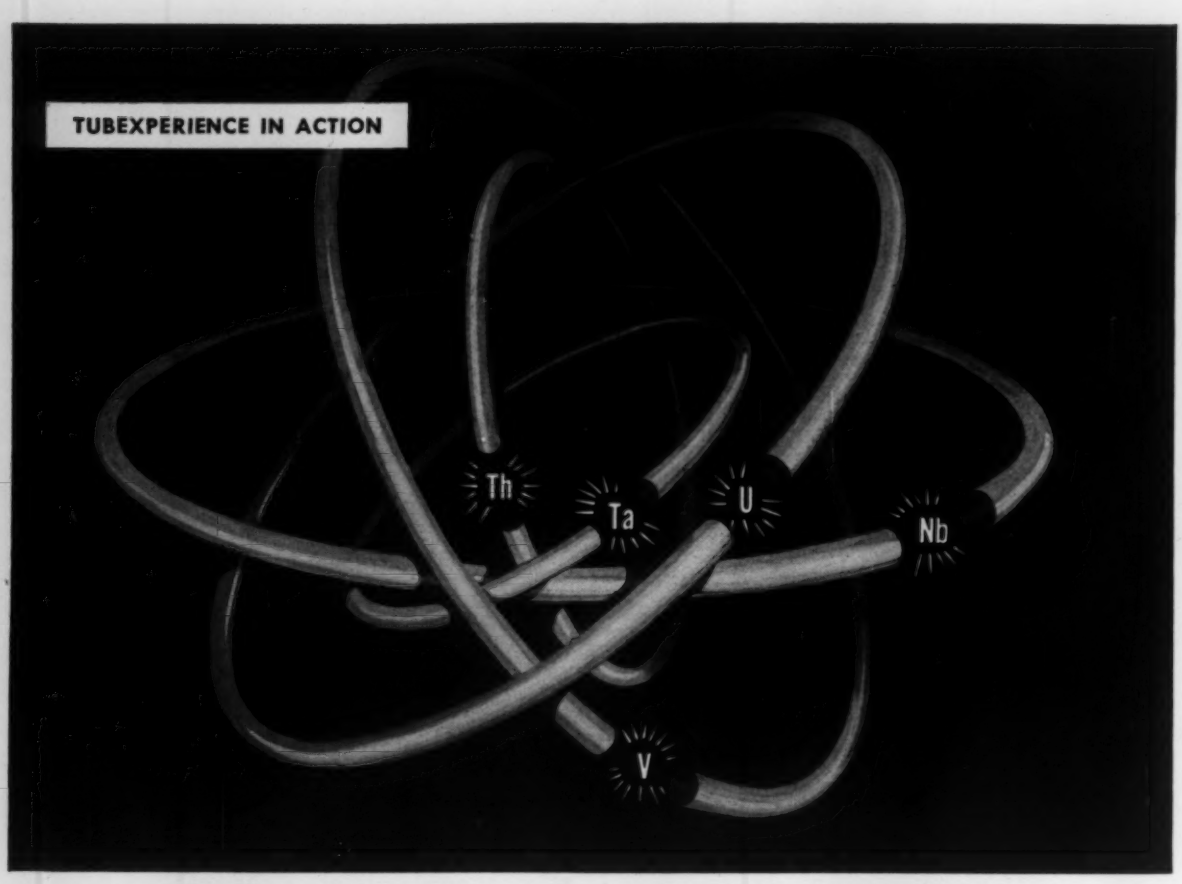

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. . . And Superior has produced all this tubing to exceptionally precise specifications and tolerances!

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NOTE: In some cases, tubing can be produced only with AEC release, because of priorities on materials.

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All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

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OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC
MELROSE 3-3511
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OVER 100 MODELS

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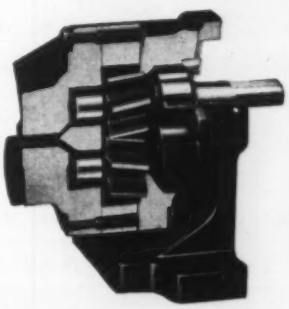

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Circle 458 on Page 19

Two at a time...

Wastebaskets molded for higher production... lower cost

A major manufacturer of metal housewares decided to broaden his line by adding plastic wastebaskets. His first step was to call in a Nosco sales-engineer . . . logical, because Nosco men are qualified plastic-parts technicians who know exactly how to put Nosco engineering and production facilities to work. The Nosco plant thus becomes the customer's own plastic molding department!

For the 8-quart basket, Nosco engineered *the deepest two-cavity mold ever built.* This hot-runner mold, which virtually eliminates all scrap, weighs more than a ton and is run in one of Nosco's large pre-plasticized presses.

The two larger size wastebaskets, pictured above, are now molded one at a time, but when production warrants, these parts can also be molded in two-cavity dies.

Nosco "Can Do" enabled this manufacturer to successfully produce deep-drawn parts at lower cost. Why not let one of our sales engineers put Nosco "Can Do" to work in designing your next plastic part? Please write.

NOSCO plastics, inc. • erie 2, pa.

World's largest injection molding plant

For other case histories—and for a glimpse of the Nosco plant and facilities, send for the free 12-page brochure, "How the Nosco Plant Works to Produce Your Needs in Practical Plastics."

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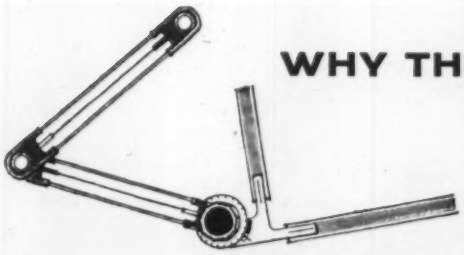
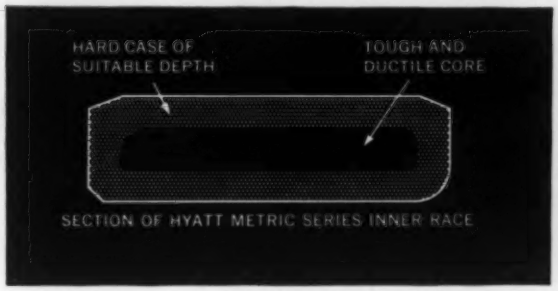
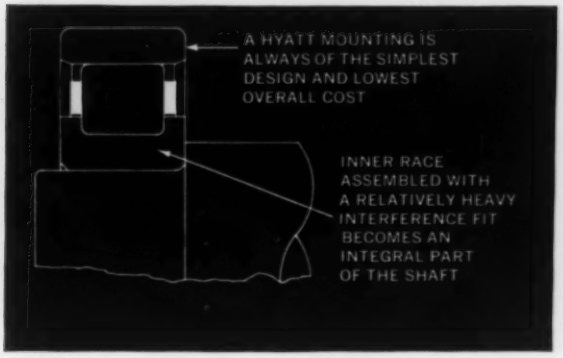


WHY THINGS RUN SMOOTHER WHEN YOU SPECIFY HYATTS

1. CARBURIZING PERMITS HEAVIER INTERFERENCE FITS



2. HEAVIER FITS SIMPLIFY MOUNTING, REDUCE COSTS


A HYATT MOUNTING IS ALWAYS OF THE SIMPLEST DESIGN AND LOWEST OVERALL COST
INNER RACE ASSEMBLED WITH A RELATIVELY HEAVY INTERFERENCE FIT BECOMES AN INTEGRAL PART OF THE SHAFT

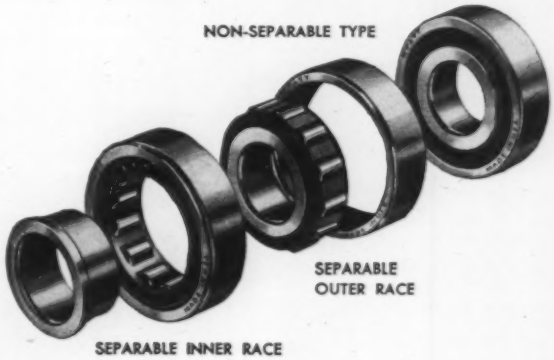
HYATT PIONEERED THE USE OF CARBURIZING TYPE ALLOYS IN ORDER TO OBTAIN THE ADVANTAGES OF HEAVIER RACE FITS

To obtain the best possible performance, roller bearing races must be assembled on shafts and in housings with fits developed by design and experience. The most frequent condition to be met is a rotating shaft where specific load and speed conditions must be satisfied with appropriate race fits. These vary according to the manufacturer, and in the case of some manufacturers, according to the application. Naturally, the fits will also vary according to bearing type and size. How HYATT achieves the optimum in heavier race fits is detailed at right.

You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Pittsburgh; Detroit; Chicago; and Oakland, Cal.

1 With the standard metric series of cylindrical roller bearings there is a choice of two fitting practices: (1) Inner races of through-hardening steel, which dictates fairly light interference fits to avoid splitting. (2) Inner races of low carbon steel carburized and hardened to develop a suitable surface hardness and a tough ductile core. The latter permits much heavier interference fits and eliminates holding devices, because the race becomes practically an integral part of the shaft.

2 HYATT originated the carburized race and relatively heavy inner race fits to simplify bearing mounting and eliminate retaining devices. Practically all HYATT inner races are made from nickel alloys of the carburizing type. They permit the simplest kind of mountings and lowest overall cost, and their shoulders will withstand considerably greater impact loads than those of through-hardened races.



THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

1908–1958 GM

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

Steel-Weld FABRICATION

Use WELDED STEEL for Greater Strength with Less Weight!

The 46-Ton Weldment, illustrated above, is one of two Reaction Girders which, after machining, will become integral parts of a 390-Ton Vertical Lift Gate in a Lock Mechanism in the Long Sault Canal at Massena, New York. Mammoth Weldments such as this Lift Gate, and the diverse pieces at left, are typical of the thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon each year for use in processing machinery, machine tools, and other types of heavy mechanical equipment. If you are not now taking full advantage of the economies offered by welded steel components in your product, you should give the matter serious thought. In the design of almost any type of heavy machinery there are parts and sub-assemblies that can be produced more economically, more satisfactorily, and in less time, in welded steel. In weldments you get greater strength with less weight—plus the additional advantages of greater rigidity and 100% predictability. When you consider weldments, you will want to discuss your requirements with Mahon engineers; because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with complete facilities for design engineering, fabricating, machining and assembling. See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

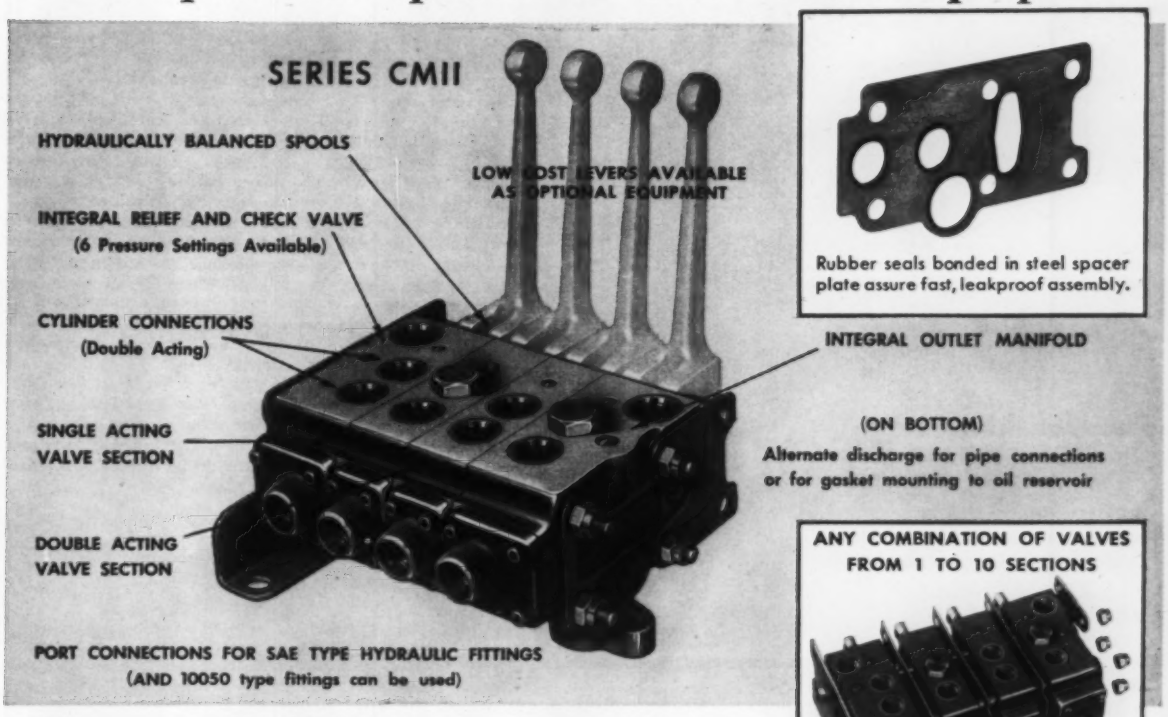
THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

For Improved Operation of Mobile Equipment


SERIES CMII
HYDRAULICALLY BALANCED SPOOLS
LOW COST LEVERS AVAILABLE AS OPTIONAL EQUIPMENT
INTEGRAL RELIEF AND CHECK VALVE
(6 Pressure Settings Available)
CYLINDER CONNECTIONS
(Double Acting)
INTEGRAL OUTLET MANIFOLD
(ON BOTTOM)
Alternate discharge for pipe connections or for gasket mounting to oil reservoir
SINGLE ACTING VALVE SECTION
DOUBLE ACTING VALVE SECTION
PORT CONNECTIONS FOR SAE TYPE HYDRAULIC FITTINGS
(AND 10050 type fittings can be used)
Rubber seals bonded in steel spacer plate assure fast, leakproof assembly.
ANY COMBINATION OF VALVES FROM 1 TO 10 SECTIONS
Easy Sectional Assembly

Improved Vickers CM11 Multiple Unit Valves

Improved control, greater convenience and economy have been provided by this new design of Vickers Series CM11 Multiple Unit Valves. They are widely used on such applications as: material handling equipment, farm tractors, construction and mining machinery, bucket loaders, and many other types of mobile equipment where accurate control of hydraulic power is required.

Simultaneous Functions

Valves may be operated individually or simultaneously. Saves operator's time on the job. Full pump delivery is available at any one valve when operated singly.

Precise Control

Improved metering characteristics and Vickers exclusive porting arrangement make possible a smooth and selective control . . . greater precision in nudging, crowding, inching and positioning. Valve spools are spring centered to neutral position and hydraulically balanced to prevent kicking-out due to excessive back pressure or surges. A check valve in the inlet prevents pressure surges at the cylinder from acting destructively on the pump.

Overload Protection

Tamper-proof integral relief valve provides excellent overload protection and low override characteristics. Relief valve is preset at factory to any one of 6 cracking pressures from 500 to 1750 psi (250 psi increments).

High Capacity

Maximum capacity is 12 gpm with three or less valve sections, or 9 gpm with over 3 valve sections. Maximum working pressure is 2000 psi.

Sectional Assembly

A high degree of control flexibility from minimum inventory is assured users requiring a variety of valve assemblies.

Seal Plate Subassembly

Steel spacer plate with rubber seals bonded in place allows rapid, leakproof assembly of valve sections. Plate subassembly permits instant, positive joining of sections with no danger of overstressed through bolts and cramped valve spools.

Minimum Space and Weight

Simplified design and construction characterize CM11 valve assemblies. Valve end sections combine in one casting the inlet or outlet manifold together with any operating valve section . . . saving space and weight.

Easy Mounting

Mounting is a simple three-point installation. Cylinder connections are ¾-16 UNF-2B thread (SAE type) . . . inlet and discharge ports are ¾-14 UNF-2B thread (SAE type). Alternate discharge connections in bottom of end sections provides for gasket mounting to oil reservoir or to ½" threaded pipe.

Interchangeability

Interchangeable valve sections assemble for both original and conversion equipment with minimum stock requirements. Added operations are quickly accommodated simply by adding suitable valve sections.

For further information, write for Bulletin M5101A.

7852

VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION
Mobile Hydraulics Division

ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

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IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto and Montreal

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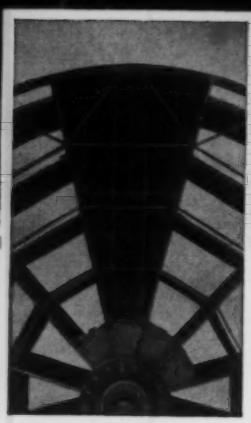
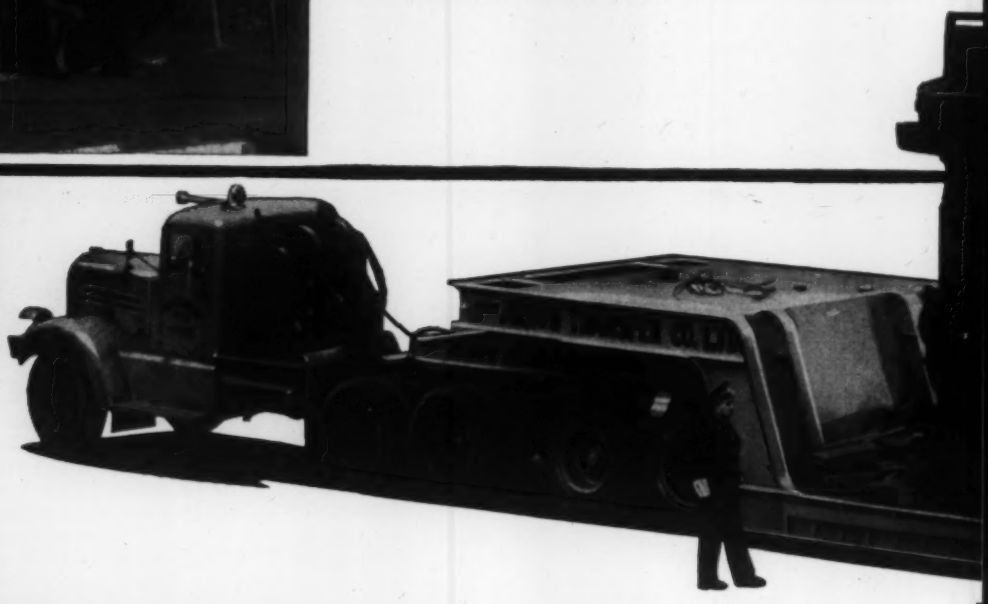
INCREASES CORROSION RESISTANCE. The huge rotor illustrated here is the main structural component of a Ljungstrom Horizontal Air Preheater. Three of these units, designed to serve a 1,900,000 pounds-per-hour-capacity boiler, are among the largest ever manufactured by The Air Preheater Corporation, New York. Each complete preheater weighs 270 tons. The rotor itself—25′2″ in diameter and 10′10½″ deep—when fully loaded with the heating element, weighs about 390,000 lbs.

Because sulfur in the gases combines with moisture—sulfuric acid is formed when the temperature drops below the dew point at the "cold" end of the rotor—corrosive action can be highly severe in this area. Corrosion means maintenance.

Aiming at a reduction in maintenance, the manufacturer cooperated with the U. S. Bureau of Mines in exhaustive tests to determine the corrosion resistance of various materials under sulfuric acid attack in air preheaters. These tests, made over a 5½-year period, showed that the corrosion rate of low-alloy USS COR-TEN Steel was *lower* than all but one of the *high* alloy steels tested, was less than one-half that of carbon steel and less than one-fourth that of cast iron.

As a consequence, USS COR-TEN Steel is specified for the cold end heating elements and containing baskets on all conventional boiler applications. Where unusually severe corrosion is anticipated, USS COR-TEN Steel is also specified in all or part of the rotor including diaphragm plates, bar stock, rim angle and filler plates.





INCREASES DURABILITY, REDUCES COST. Tote boxes have to take quite a beating. Used for handling, storing and shipping automotive and other parts, they must be able to withstand plenty of rough treatment.

That's why the "Hamlintainer" shown here—a *collapsible* tote box that sets up and folds flat in less than 20 seconds—is now built entirely of USS COR-TEN Steel. COR-TEN Steel's greater strength, 50% higher than carbon steel, makes it possible to build the "Hamlintainer" up to 100 lbs. lighter than carbon steel units, yet so strong and rigid that it will withstand long and rugged service and is not susceptible to bending and distortion. The fact that the COR-TEN Steel ends and sides have the stamina needed to maintain their shape permanently is of utmost importance. It means that throughout its long life the box will always be easy to set up, fold and stack flat.

As compared to the metal construction used in an earlier design, USS COR-TEN Steel makes the "Hamlintainer" not only stronger, more rigid and more durable but also less costly to produce, according to the manufacturer, Hamlin Metal Products Co., Akron, Ohio.

1933
1958

USS HIGH STRENGTH STEELS

25 YEARS OF PERFORMANCE

High-strength USS COR-TEN Steel pays off in equipment like this

What does your product need to make it better? Greater durability? Bigger capacity? Cheaper maintenance? Lower operating cost?

Do you want to make it stronger, lighter in weight, more corrosion resistant, better able to withstand abrasion, impact and fatigue?

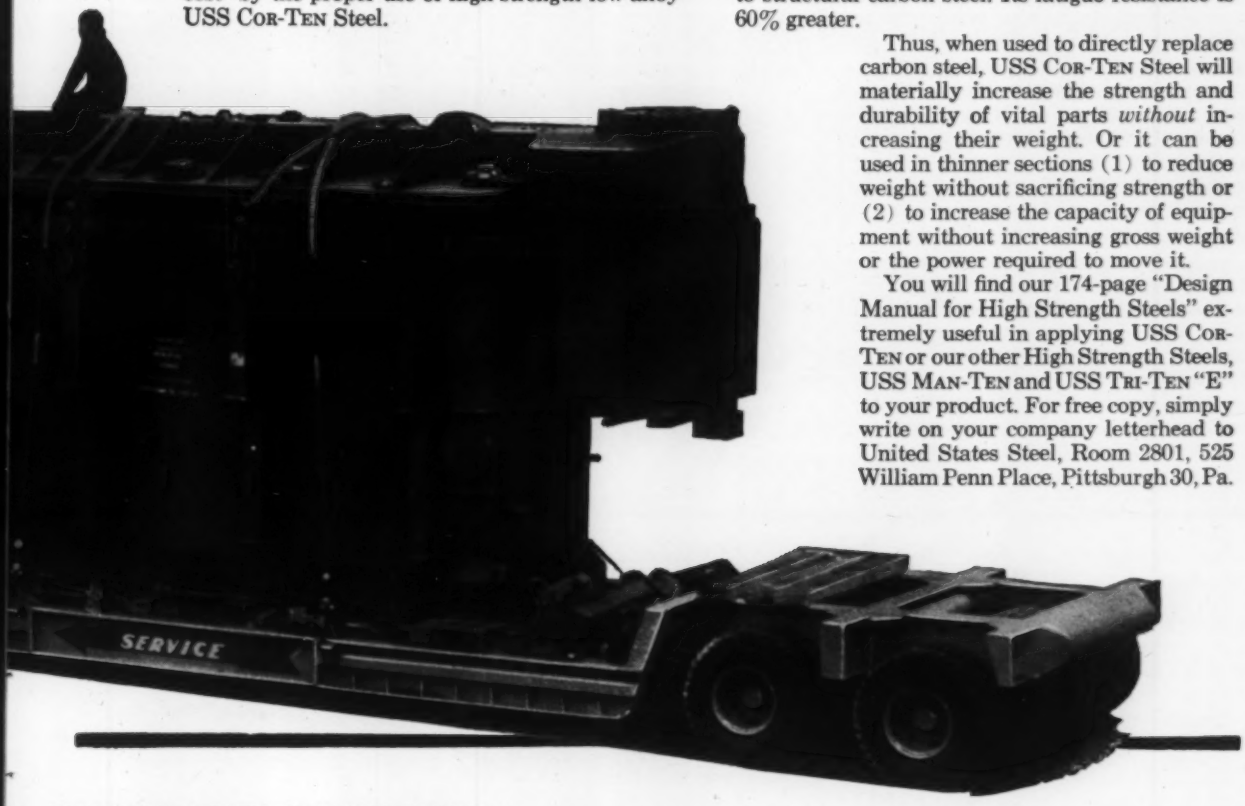
You can obtain any or all of these important money-saving benefits—at little or no increase in cost—by the proper use of high-strength low-alloy USS COR-TEN Steel.

USS COR-TEN Steel is distinguished by its superior resistance to atmospheric corrosion—4 to 6 times that of carbon steel, 2 to 3 times that of copper steel.

In thickness of ½" and under, COR-TEN Steel has a minimum yield point of 50,000 psi and a minimum tensile strength of 70,000 psi. In resistance to abrasion, shock and impact, it is superior to structural carbon steel. Its fatigue resistance is 60% greater.

Thus, when used to directly replace carbon steel, USS COR-TEN Steel will materially increase the strength and durability of vital parts *without* increasing their weight. Or it can be used in thinner sections (1) to reduce weight without sacrificing strength or (2) to increase the capacity of equipment without increasing gross weight or the power required to move it.

You will find our 174-page "Design Manual for High Strength Steels" extremely useful in applying USS COR-TEN or our other High Strength Steels, USS MAN-TEN and USS TRI-TEN "E" to your product. For free copy, simply write on your company letterhead to United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.



INCREASES STRENGTH, SAVES WEIGHT. Shown here hauling a 117-ton transformer, this 150-ton-capacity trailer—built by Columbia Trailer Company, Vancouver, B. C., for the Arrow Transfer Company of that city—is the largest trailer ever built in Canada.

This 80-ft.-long trailer is constructed almost entirely of USS COR-TEN Steel. It is about 25% lighter than if it had been built of structural carbon steel. Specifically designed for handling transformers of giant size, it has a depressed center deck which makes loading and unloading easier and keeps center of gravity low to prevent danger of upset.

Says the manufacturer: "We have found that when a trailer is made from structural carbon steel there is a greater possibility that it can be permanently damaged from overloading than in the case of a similar unit made from high strength steels. That's why, in designing trailers of this type, we always use USS COR-TEN Steel. This construction gives us the high strength needed, plus excellent corrosion resistance and freedom from excess weight—all very important in equipment like this."

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

UNITED STATES STEEL

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TIMERS...SPECIAL DELIVERY

Standard or special— Industrial Timer makes rapid deliveries on all models

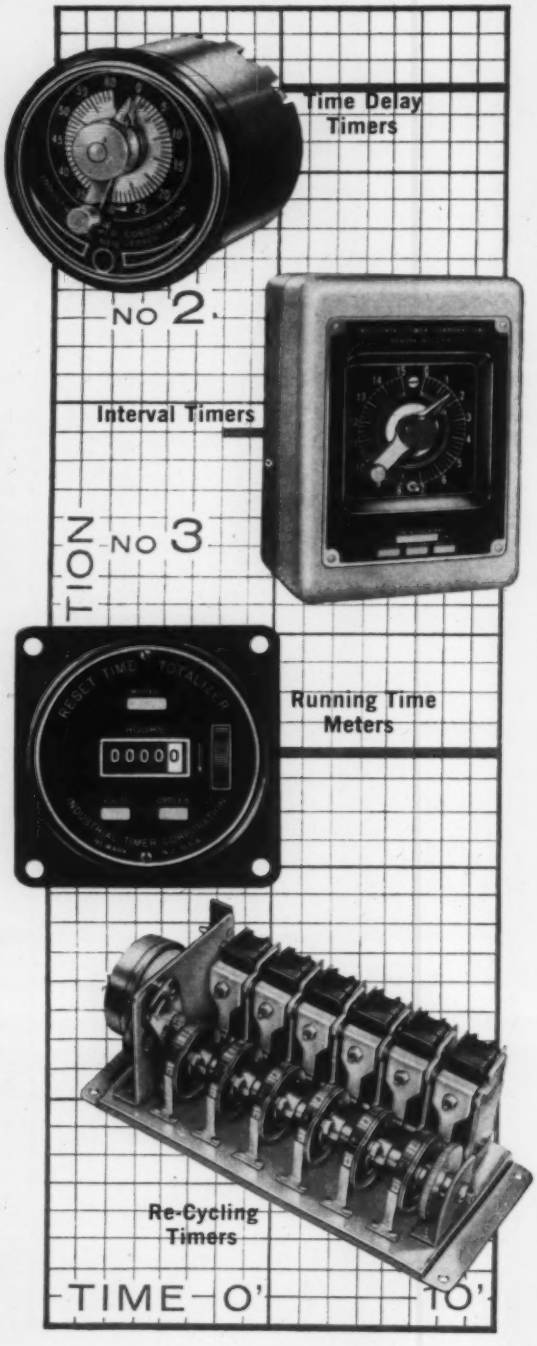
Sometimes you need a standard model timer . . . other times you need a special. Either way we can give you the extra rapid service you may need because of the efficient way we design, manufacture and stock timers for industrial applications.

To meet *all* of the widely varying needs of our customers we manufacture a complete line of timers in the four broad classifications illustrated here:

1. TIME DELAY TIMERS
2. INTERVAL TIMERS
3. RE-CYCLING TIMERS
4. RUNNING TIME METERS

From these we have already developed 20 basic types which can be combined in endless number of ways . . . to date, our engineers have combined them into over 1000 different models. So what might seem to be a special timer requirement to you, will very often be a standard timer in our large stock, and that is the reason we have the ability to fill special orders so quickly. And as far as standard timers are concerned we can give overnight service if necessary.

So, for the utmost in all-round service depend on us for this outstanding combination: deliveries "Immediate on Standards . . . First on Specials".



Speed up your automatic control projects— profit by our timing application experience

No need to let timing problems delay you in your automatic control projects when you can place them with us and get faster solutions. Even though no two automatic control jobs are ever exactly alike, and even though the timer requirements of each are very different we have established an excellent record in helping out in these situations.

20 years of experience in analyzing complex timer applications has provided us with the special knowledge required to give our customers the right answer in near-record time.

Our large stock of standard and combination timers enables us very often to fill orders for these requirements without any time loss because we have already developed so many new combinations specifically for automatic control functions.

Extra special automatic control timer — this calls for original designing. Our engineers will go right to work and get the job done. That's the way we grow and we like it.

Whatever your control problem, you have everything to gain by submitting it to our timer specialists. They'll come up with the answer — almost with the speed of automatic control itself.

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

1413 McCARTER HIGHWAY, NEWARK 4, N. J.

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Armstrong FRICTION MATERIALS...

eliminate clutch failure under severe operating conditions

Road races and cross-country endurance runs are severe tests for all the components of a motorcycle and particularly for the clutch facings.

The Triumph motorcycle clutch shown above has to engage quickly at speed differentials as high as 4,000 rpm, at full throttle, as many as 20 times a minute. At top speed, the motor develops 45 to 50 hp. The clutch plates are splash lubricated with oil at ambient temperatures of 250° F.

In testing materials to find one that could stand up under these conditions, Triumph engineers selected Armstrong NC-733. This cork-rubber facing engaged almost instantaneously, even when soaked with oil, reducing the heat generated by excessive slippage. A faster engagement also gave Triumph a competitive speed advantage by cutting seconds off shifting time.

By making Armstrong NC-733 the standard material for all heavy-duty clutches, Triumph has now eliminated burned facings and resulting clutch failure.

Whatever your application for resilient friction materials, you'll find the right facing for your requirements among the many in the Armstrong line.

Send for informative booklet

A new booklet describing our full line of resilient facings has just been published. Write today for your copy of "Armstrong Resilient Friction Materials." Armstrong Cork Company, Industrial Division, 7202 Dean Street, Lancaster, Pennsylvania.

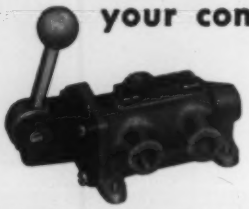
Armstrong RESILIENT FRICTION MATERIALS

... used wherever performance counts

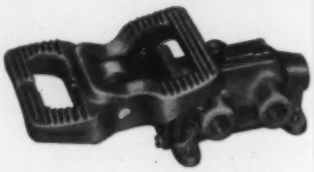
Schrader®...

your one source for AIR VALVES

full line for every use—immediately available from your conveniently located Schrader Distributor

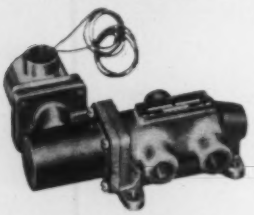


Hand-Operated Four-Way Valve



Foot-Operated Four-Way Valve

Pilot-Operated Valve



Solenoid-Operated Valve

Rotor Type Valve

Cam-Operated Valves

Flow Control Valves

Quick Exhaust Valves

Two- and Three-Way Poppet Type Valves with Roller Lever

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a division of **SCOVILL**

Schrader's complete air products line can meet your every need.
A. SCHRADER'S SON • *Division of Scovill Mfg. Co., Inc.* • **BROOKLYN 38, N. Y.**

QUALITY AIR CONTROL PRODUCTS

Circle 466 on Page 19

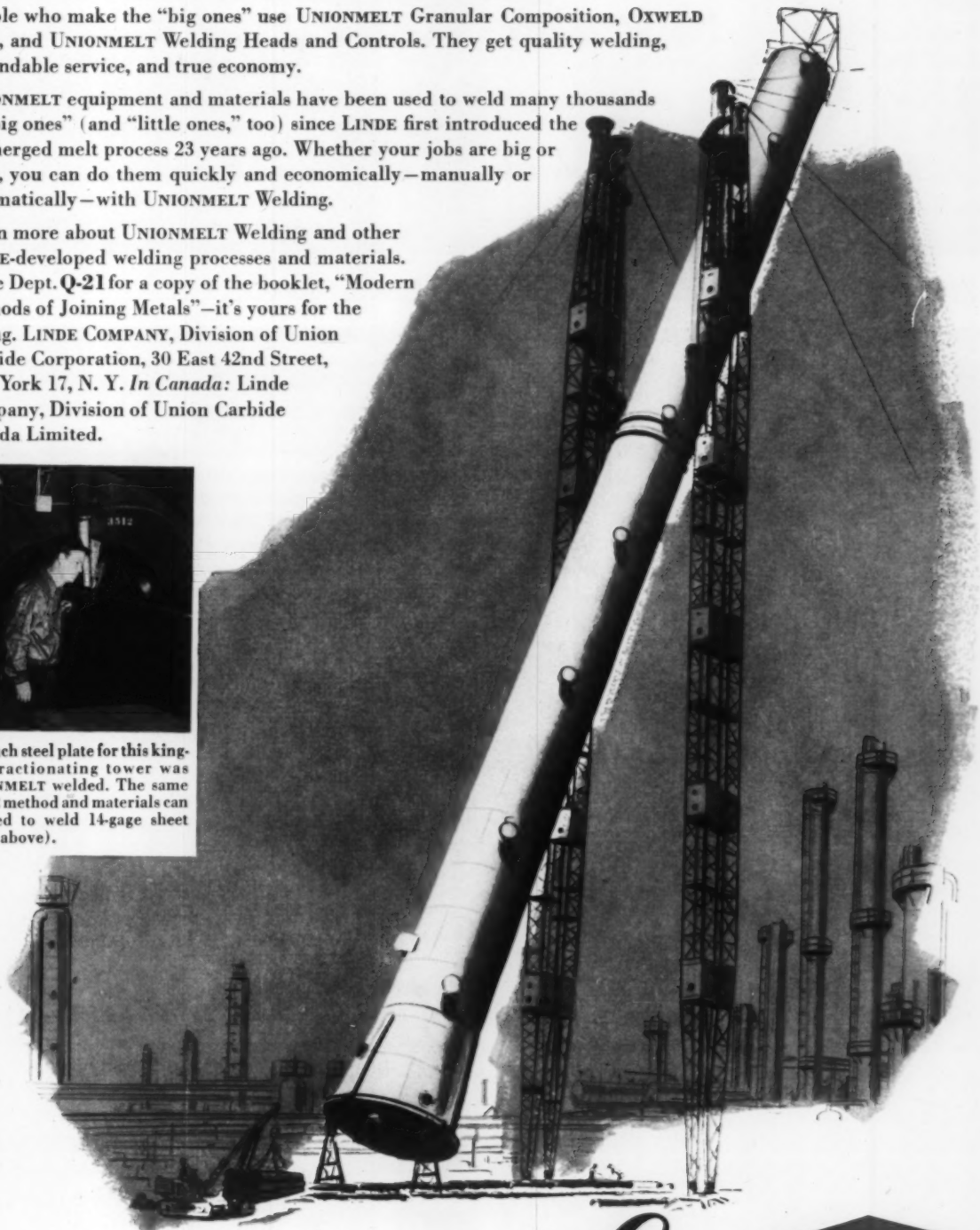
UNIONMELT Welding
makes short work of tall towers

People who make the "big ones" use UNIONMELT Granular Composition, OXWELD Wire, and UNIONMELT Welding Heads and Controls. They get quality welding, dependable service, and true economy.

UNIONMELT equipment and materials have been used to weld many thousands of "big ones" (and "little ones," too) since LINDE first introduced the submerged melt process 23 years ago. Whether your jobs are big or little, you can do them quickly and economically—manually or automatically—with UNIONMELT Welding.

Learn more about UNIONMELT Welding and other LINDE-developed welding processes and materials. Write Dept. **Q-21** for a copy of the booklet, "Modern Methods of Joining Metals"—it's yours for the asking. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

One-inch steel plate for this king-size fractionating tower was UNIONMELT welded. The same LINDE method and materials can be used to weld 14-gage sheet steel (above).



Linde

UNION CARBIDE

The terms "Linde," "Unionmelt," "Oxweld," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

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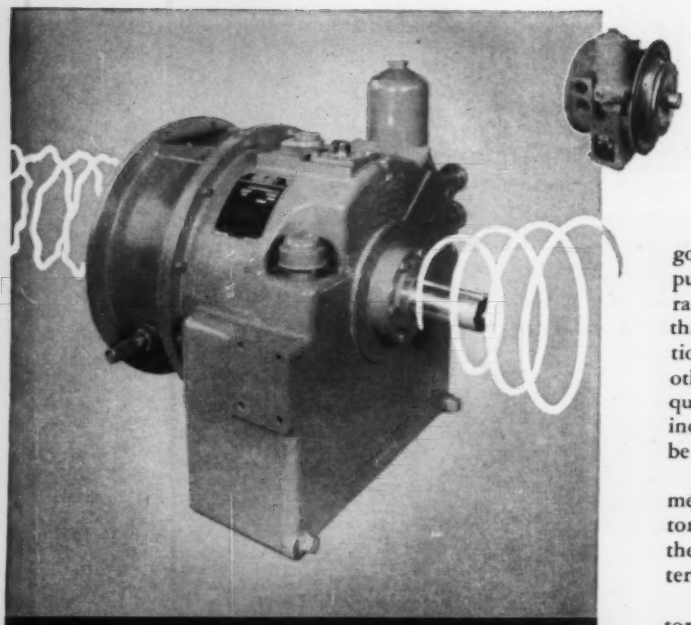
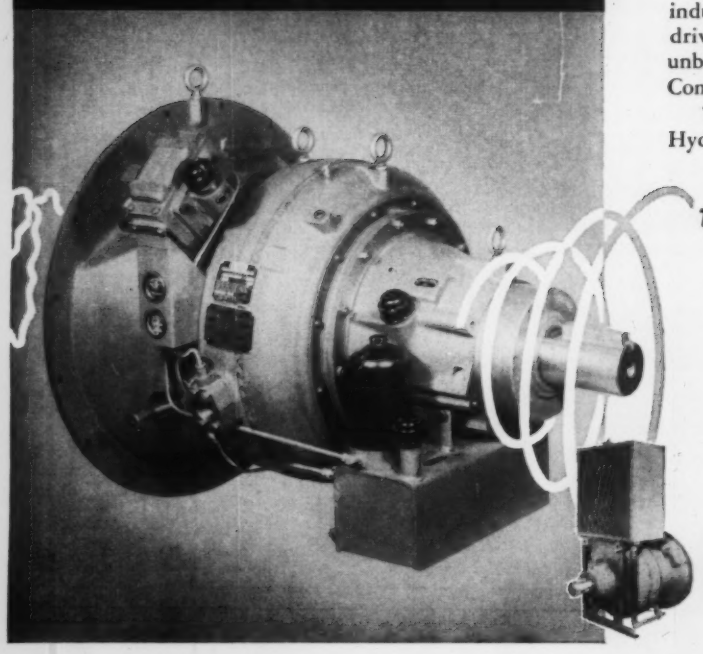


Single-Stage Torque Converters or Three-Stage Torque Converters?



The answer to the question of "single-stage vs. three-stage" depends largely on the characteristics of the equipment you manufacture or use and the jobs it is required to do. Naturally, many factors must be known before any engineering department can be expected to make recommendations.

Generally speaking, however, when it is desired to have minimum pulldown from governed engine speed—with maximum power output over a wide range—and to produce high torque ratios for hoisting or heavily loaded vehicles, a three-stage torque converter, with torque multiplication up to six times, may be most desirable. On the other hand, where mild torque conversion is required, as in certain types of vehicles and in other industrial equipment—a single-stage converter may be the best choice.

Now you can benefit from the unbiased recommendations of one manufacturer in choosing a torque converter—single-stage or three-stage—with the exact capacity and torque transmission characteristics to give your equipment maximum efficiency.

Twin Disc Clutch Company's line of single-stage torque converters—available as the 1300 and 1500 Series units—complements its time-tested, universally accepted line of five series of three-stage units. Single-stage *or* three-stage—from 30 to 1000 hp—you can depend on Twin Disc Torque Converters to give your equipment better performance . . . less downtime . . . and greater earning potential.

In addition to offering the most complete, the most versatile line of industrial torque converters available, Twin Disc manufactures fluid couplings in a wide range of sizes for engines and motors from ¾ to 850 hp, and friction clutches for applications from fractional to 1050 hp.

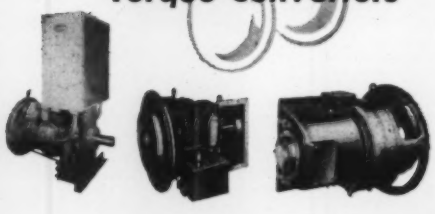
For smooth, dependable transmission of power to your equipment and machinery, standardize on Twin Disc—the world's leading manufacturer of industrial fluid and friction drives. Whatever your drive problem, you can count on Twin Disc for unbiased recommendations . . . for Twin Disc Clutch Company makes them all.

Twin Disc Clutch Company, Racine, Wisconsin; Hydraulic Division, Rockford, Illinois.

TWIN DISC MAKES THEM ALL

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Torque Converters



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MACHINE DESIGN
February 6, 1958

Men of Quality

THE ENGINEER has been described as a scientist with a sense of urgency. Not content with scientific knowledge for its own sake, he is compelled to do something about it for the benefit of mankind.

So the most effective engineer is the one who can get things done—the creative engineer. The engineer who feels unrecognized might well take a long hard look at himself to determine whether he is a truly creative engineer or perhaps only a hard-working technician.

Not all of us can be creative geniuses. But there are well recognized elements of the creative process which anyone can apply with more or less success. In his lively and thought-provoking article in this issue, Harold Buhl includes seven steps in creative problem-solving which are a useful guide.

More broadly, John Arnold has suggested five attributes of the creative engineer, who

1. Is motivated by broad concepts of human activity, thought, and behavior.
2. Understands and knows what he is designing for and the environment in which his product will be conceived, made, marketed, and used.
3. Is articulate in communication—written and spoken, symbolic and visual.
4. Has balanced ability to analyze, synthesize, and evaluate.
5. Understands and can master the creative process.

The current period of economic readjustment, or whatever you choose to call it, seems to confirm the contention that the recent shortage of engineers was one of quality rather than quantity. The quality shortage is still very much with us, and will be for the foreseeable future.

Job security, therefore, lies in being numbered among the men of quality—the creative engineers.

Colin Carmichael

EDITOR

History gives a lesson in

APPLYING CREATIVITY

to speed engineering development

There's nothing new about creativity —whether it is called idea-getting, problem-solving, or inventing. History records engineering developments that certainly reflect great creativity. From the vantage point afforded by today's systematic problem-solving techniques, we can look back and try to see why these things were so long aborning. Such an analysis, and an outline of the systematic approach, are presented here.

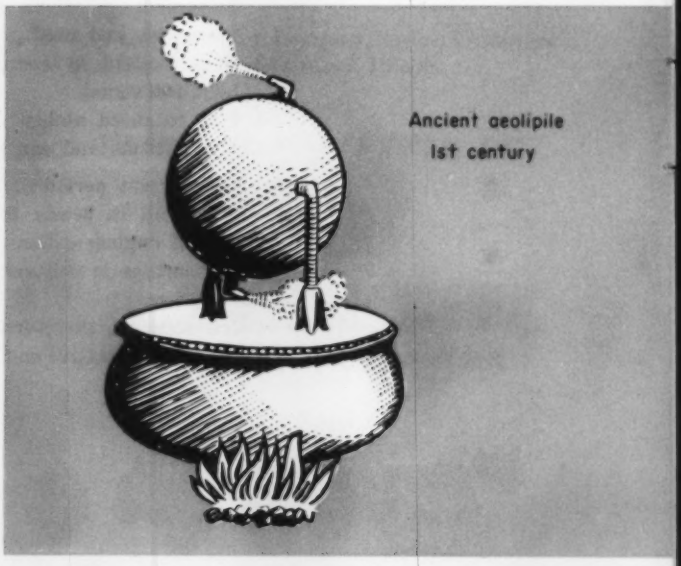
CHILDHOOD memories always seem to hold a firm and revered place in our hearts. The engineer also seems to remember fondly the men and machines of his early years—the puffing steam locomotives, the chugging, noisy steam engines at the power plant, the chain-driven Mack trucks. Through the years the ice boxes and pot-bellied stoves have been replaced with more convenient self-defrosting refrigerator-freezers, certainly more labor-saving gas furnaces and air conditioning. The steam shovel has been replaced by the more efficient and versatile crawler tractor. These things and more have changed steadily through the years.

All this is mentioned, not to point out that "you never had it so good," but to repeat the often-asked question: Why couldn't all these developments have come sooner? Couldn't we have had today's inventions yesterday; can't we have tomorrow's today? Perhaps we can.

"Obvious" Solutions

An unusual aspect of the way we think is the fact that once a solution has been found to a problem, the solution appears extremely simple. We say to ourselves, "Why didn't I think of that?" or "That's obvious." Yet histories of various projects show that their solutions were neither simple nor obvious—that much time and labor and sweat were expended to find the answers.

Why were many inventions long aborning? Certain inventions had to wait for key materials, theories, or ideas. Radio waited for DeForrest's vacuum tube, transportation waited for the gasoline engine, most machines waited for steel. However, there are many inventions which were long in coming even though the need, the materials, the know-how were all available. It was just a matter of putting all the pertinent data together in an actual solution. It is with this group that we are here concerned. Why did they take so long to be invented or developed? What could be done to speed up invention so that tomorrow's developments could come today? What can be done so that so many intermediate and stop-gap solutions can be avoided?



By HAROLD R. BUHL
Assistant Professor of Mechanical Engineering
Iowa State College
Ames, Iowa

History of Harnessing Steam

A bit of engineering history[1] will show why several inventions were not made sooner. Newcomen presented his atmospheric steam engine to the public in 1712. This engine, the first practical application of steam to useful work, functioned by introducing steam into a single-acting single cylinder. The piston was connected through a rocking beam to a single-acting pump. The steam was condensed in the cylinder by the injection of cool water. The resulting decrease of volume in the cylinder allowed the piston to move downward under atmospheric pressure. While being the first practical engine, it certainly possessed disadvantages to even the casual observer. The low efficiency—1 per cent—resulted in extremely high fuel consumption. It produced low power despite its large size and was adapted only to pumping. No rotating motion—hence, no locomotion—was possible. The problem areas consisted then of poor efficiency, adaptability, size, and power.

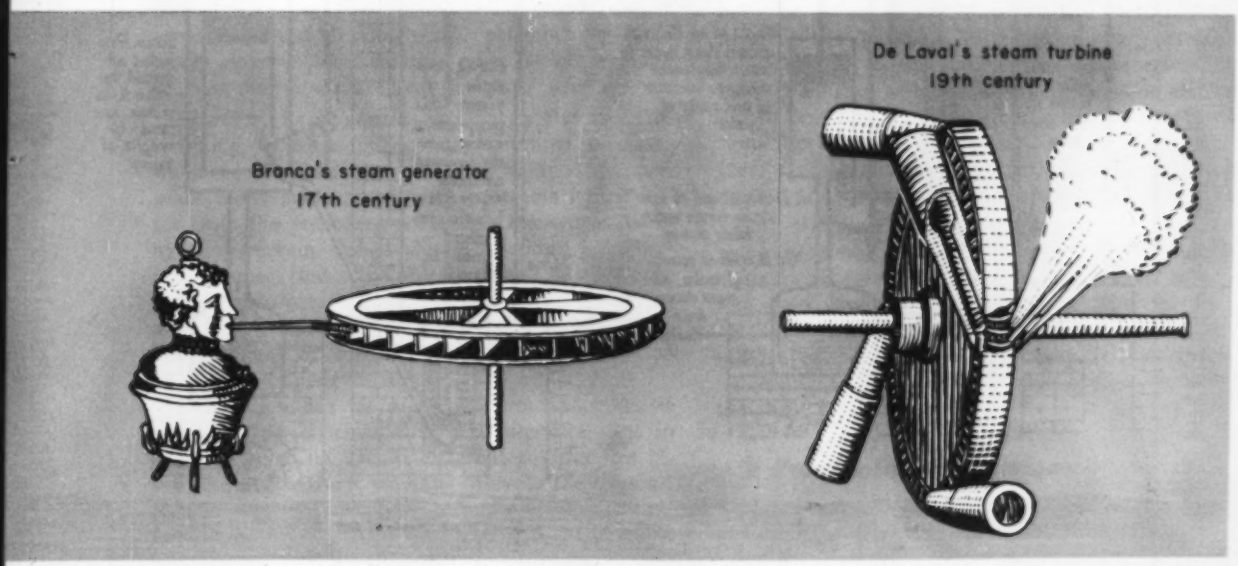
Suppose some enterprising young man had sat down to consider the problem. Suppose he had said, "Just what is the problem? What can I do differently? What can be done another way? What would happen if I did this? What could I omit, combine, reverse?[2] What is unnecessary?" If he had deliberately followed such a procedure, could he have accomplished something?

Sixty-Five Years Later: It was not until 1777 that Watt came out with an improved engine. The condensing was accomplished outside of the cylinder in a separate condenser (where else? separate). The cylinder was insulated, thus eliminating the inefficiency due to cyclic changes of temperature within the cylinder. It must be remembered that the principles of thermodynamics and heat transfer were not available to these men. The piston became double-acting (add, multiply). The engine speed became controlled by the flyball governor (adapted from mills). Here was the result of a distinct effort to improve a product and to eliminate systematically the undesirable features.

However, as unconventional as Watt seemed to be, he made no effort at first to adapt the engine to other uses (rotary motion). He kept the beam arrangement, which decision necessitated the invention of the Watt straight-line mechanism in order to keep the piston rod acting in a straight line. Evans later invented the grasshopper mechanism which obviated the need for a straight-line mechanism such as Watt's. Watt continued to experiment with atmospheric-pressure engines.

The lessons that may be learned from this account of the steam engine is that a systematic approach to a problem can help in its solution. It is furthermore apparent that a deliberate attempt must be made to get away from the obvious, the normal way of doing things. Unless one makes a conscious effort to get out of the rut, he falls

[1]References are tabulated at end of article.



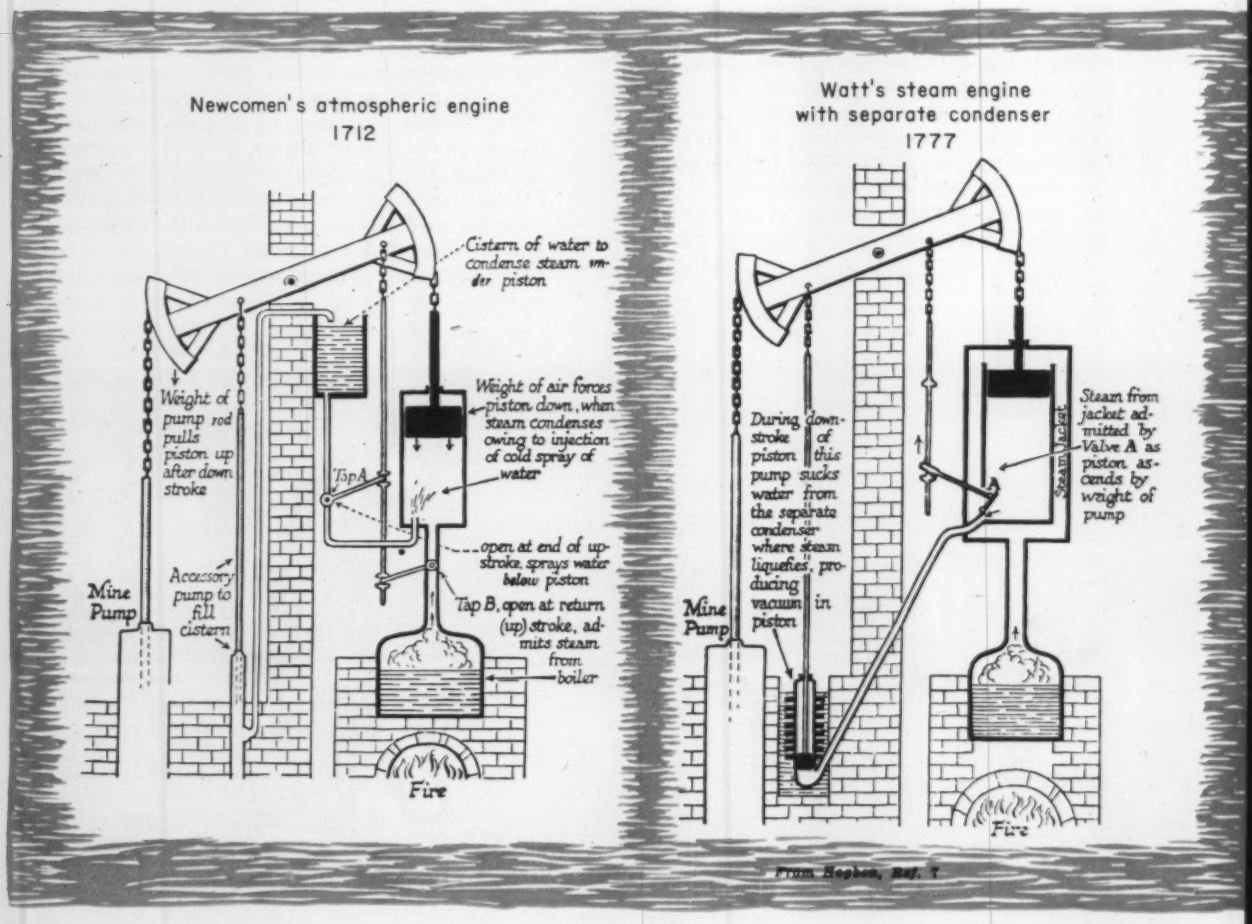
into the trap of continuing to do things the way they've always been done.

The Steam Turbine: Predecessors of the steam turbine were Hero of Alexandria's aeolipile, developed just after the beginning of the Christian era, and Branca's very fancy impulse turbine complete with the replica of a man's head blowing out steam (1629). Yet it was not until 1882 that De Laval developed a practical steam turbine. There was much toying in the intervening years, and it appears that a more deliberate approach could have overcome the difficulties. It is true that the turbine required steel to be successful, but Bessemer had already produced his invention in 1856. The tools already existed at an early date, and certainly a need was present. It seems difficult to justify all this foot-dragging except by concluding that the approach to the solution could have been improved.

The Scientific Method

But, one might argue, this is history—since these early days of the industrial revolution, we have developed a scientific method; we have learned to invent and to design. True, we have come part way. But look at any one field of engineering. How many developments in this field were truly inventions, creative solutions to problems? Aren't most of these developments merely changes in devices that have existed for some time?

What about modern times? It is always interesting to speculate what the history of aviation would have been had the early experiments with rotary-winged aircraft been successful before the days of Kitty Hawk. Many were the experiments before the days of the successful first flight by the Wright brothers, even experiments by the eventually successful Sikorsky. The difficulty was that the plane could not be controlled. Not only did Da Vinci (1500) draw a screw-type helicopter, but in 1878 Forlanini made a slightly successful steam helicopter, which reached an altitude of about 4 ft. Gasoline engines became available in about 1876 (Otto). In 1922 Juan de la Cierva experimented with the autogyro and concluded that the blades could be hinged at the hub, that the pitch of such blades could be controlled, and that the axis of the rotor could be tilted. These are all necessary ingredients of a successful helicopter. However, it was not until 17 years later that Sikorsky successfully flew a practical helicopter. Could this time have been shortened by utilizing an improved approach?


Newcomen's atmospheric engine
1712
Cistern of water to condense steam under piston
Weight of pump rod pulls piston up after down stroke
Weight of air forces piston down, when steam condenses owing to injection of cold spray of water
Tap A
open at end of up-stroke sprays water below piston
Tap B, open at return (up) stroke, admits steam from boiler
Accessory pump to fill cistern
Mine Pump
Fire
Watt's steam engine
with separate condenser
1777
During down-stroke of piston this pump sucks water from the separate condenser where steam liquefies, producing vacuum in
Steam jacket
Steam from jacket admitted by Valve A as piston ascends by weight of pump
Mine Pump
Fire
From Hogben, Ref. 1

There are other fields—self-defrosting refrigerators, jet engines, developments on the railroads, cars, automatic controls, and others. Why were these not available at an earlier date? The need, materials, theories, were all available many years earlier. There must have been some common cause, some common missing ingredient. Very likely this ingredient was a creative systematic approach to these problems. With an improved approach we can probably speed-up invention and make it more efficient.

The foregoing discussion is not meant to minimize the efforts of the men involved; their contributions to history are solid and their places are secure. It is not a matter of hindsight or second guessing. It's just a matter of profiting from past mistakes.

An interesting account of the thinking involved in the solution of an engineering problem is reported by Wertheimer[3] and concerns the procedures and thoughts that led Einstein to his theory of relativity. It is fascinating to view the development of his thoughts and to wonder why the data collected in the Michelson-Morley experiments in 1885 could not have also led others to similar conclusions, perhaps at earlier dates.

If there is a possibility that these inventions could have occurred at an earlier date, why didn't they? What could have been done differently? What could we do so that our real and creative solutions come as early as possible? The solution involves two closely related areas—why we don't develop creative ideas, and how we go about solving problems.

Problem Solving by Habit: In trying to solve problems each day, we must resort to our memory of former problems and their successful solutions. We then attempt to solve the new ones in the same manner even though the conditions may not be identical. This is all well. We need to handle some situations in a habitual manner. If someone were to attempt to drive from city to city, consciously solving each problem of brake, clutch, accelerator and steering wheel, probably he would never make it. Much routine must be left to habit so that our minds are free for more useful work.

However, habit serves as a large flywheel, attempting to force one to use previous solutions when he shouldn't be using them. It often presents ready-made answers to problems which differ from the preceding problems. One learns thereby that certain things should be done in a certain manner, that some objects should be used only for certain operations. A hammer is for pounding nails, not a weight or a pendulum. A ball is a toy, not a means of supporting loads at low friction or a means of distributing ink.

Habit then has its place. For routine tasks it serves as an efficient source of answers. But in order to come up with a different solution, an invention or discovery, we have to avoid the obvious, the old solutions. We have to make a conscious effort to overcome habit. We have to learn to question all we know.

The individual, if he is to find new, creative answers, must be unconventional, must do things in ways not tried before. He must be a nonconformist, risking the criticism of others for not being average. He must be willing to take a calculated risk, to be willing to make mistakes despite the probable effect on his associates and superiors. He must have a liking to manipulate ideas in unique situations, to ask seemingly stupid and unconventional questions to get at the fundamentals of the problems. He must have a drive to carry on an idea despite failure and adversities even though to others he may appear stupid and bullheaded. He may appear to be a trouble-maker because he must be dissatisfied with things as they are.

The Need for Fresh Thoughts: How does this apply to the discussion of engineering history? In order for Watt to have improved on Newcomen, he must have been willing to admit that despite the ingeniousness of the original engine, it also had some drawbacks. Here was something accepted for almost 65 years. People had become accustomed to it and saw it as an obvious way of solving a problem. But Watt had to be able to see that there were also other ways of doing the job and that perhaps some of them were even better. He had to have confidence in himself; if anyone could do the job, he could. He had to have values within himself so that when all the experts and friends said that there was no other way, he could still convince himself that they were wrong.

Einstein worked for seven years on one problem. It would have been easy to accept the verdict of others. Sikorsky and others had to be different from the average to succeed. The fundamental difference that sets such men apart is not intelligence or genius, but the developable personal factors mentioned earlier.

These then are the factors which affect creative output—the psychological factors. In every step, every aspect of the problem-solving procedure, care must be taken to introduce all the factors pertinent to the problem, to consider every possible solution, and to carefully evaluate and select the most promising solution. Thinking must be deliberate to preclude introduction of personal considerations in the procedure and to keep one's mind truly free to analyze and synthesize all the information and ideas in every conceivable combination.

But we must have a framework in which to solve problems. Since habit also has a place in thinking to free us of more routine tasks, to permit us to work in such a manner that we don't forget or neglect anything, we can reserve our minds for the truly creative tasks. It is therefore necessary to consider a possible system for solving these problems.

▶ Problem-Solving Technique

The essential aspects of problem solving were discussed by Graham Wallas[4] in 1926. His conclusions are based on the work by Henri Poincare[5]

who in 1908 recorded his procedures for solving problems. Jacques Hadamard[6] in 1945 supported the proposed ideas.

Since the early days others have agreed that—particularly in science and engineering—there appears to be a series of steps or considerations which maximize the likelihood of creatively solving a problem. It should not be understood, however, that these steps must be always followed in the order given. It is often necessary to repeat, backtrack, or to mix up the steps. It should also not be assumed that we are always conscious of these steps. It is only proposed that in some order, all these steps are followed in solving problems, whether or not we are consciously and deliberately adhering to them.

These steps in problem solving are:

1. *Realize a problem* and decide to do something about it.

2. *Define the problem* specifically, separating the cause from the effects, the symptoms from the disease, deciding on limitations and goals.

3. *Gather all pertinent data,* ideas, facts, and opinions, both verbal and written—anything that might be used in solving the problem. This phase includes all past experiences, all past education, all solved or unsolved past problems.

4. *Analyze and dissect material* gathered, finding common points, points of difference, patterns, origins, trends, similarities among all the data collected. This, of course, also constitutes a weeding-out process, an elimination of incompatible information.

5. *Synthesize results* of this analysis into new patterns and new designs, and new combinations. This is perhaps the most difficult step of all, for it requires the destruction of old ideas and habits and the formation of new and sometimes ominous patterns. This step often requires considerable time. We may try "everything" and become discouraged. But a feeling is present that there must be a solution somewhere, that somehow a solution is possible. We often give up only to return again and again.

6. *Stop conscious effort* to solve the problem. A solution often appears at a time when we are no longer thinking of the problem. It takes place when we are relaxing or doing something not connected with our attempt to solve the problem. Apparently the defenses of the mind which were resisting the impending changes of habit become weak, and the mind becomes free to see new combinations and patterns. The solution appears as a whole and devoid of detail. But with the solution comes the assured feeling that it will work and that "this is it."

7. *Evaluate and develop.* It still remains necessary to work out the details, to make checks and calculations, to test the solution and to sell it to someone. Too much emphasis cannot be given to the fact that illumination is not the end of the problem, but merely the beginning of the end. There is not a phase we can call creative and another one which we can label noncreative. In every step of the procedure, the engineer must be conscious of factors working against him. He must watch out that he isn't thinking habitually, that he isn't discarding an idea because of the limitations as to what he thinks a thing should be used for or how it should be utilized.

Application of the Technique: How does this problem-solving method tie in with the engineering history discussion? Try the Newcomen-to-Watt play. If you lived shortly after the Newcomen engine was invented, you would have to realize that all such projects result in problems. What is wrong with the design, what are its limitations, where does it fail? How can its use be extended? Through conscious and deliberate effort you would realize that it was limited to pumping water, that perhaps its use could be extended. You would realize it was cumbersome and large and that somehow there must be a better way to operate than to alternately heat and cool the cylinder. Perhaps some operations could be combined, done differently, separated, simplified. You would then proceed to collect all the pertinent data, and decide what phases of subproblem you would tackle.

You would then disassemble the information and dissect it. It was certainly necessary (or was it) to cause a change of volume. But could it be done elsewhere? What other way was possible? The operation might be speeded up, or perhaps the number of events which occur at the same speed could be multiplied. If the events were multiplied (double acting), what other problems would result? If the steam pressure were increased, what would result? How could the use of this mechanism be extended? (This question never occurred to Watt, for he did not consider rotary motion until 1781 when he was urged into such consideration by Boulton.)

Through this analysis gradually it would become apparent that the primary aspect of the problem lay in the introduction of cool water to condense the steam within the cylinder. There would then come a searching for a possible solution. What else can be utilized? Where else can this even occur? What other sequence can be tried? Can something be added, omitted, separated? This self-questioning would continue until illumination would finally occur. The answer did appear when Watt didn't expect it. He recounts the event as follows:

> It was in the Green of Glasgow. I had gone to take a walk on a fine Sabbath afternoon. I had entered the Green by the gate at the foot of Charlotte Street—had passed the old washing-house. I was thinking upon the engine at the time and had gone as far as the Herd's house when the idea came into my mind, that as steam was an elastic body it would rush into a vacuum, and if a communication was made between the cylinder and an exhaust vessel, it would rush into it, and might be there condensed without cooling the cylinder. I had not walked further than the Golf-house when the whole thing was arranged in my mind.

The same thinking occurred more recently with

Einstein.[3] Einstein realized a problem, an inconsistency of Newton's theory with phenomena observed by Michelson and Morley in 1885. For seven years the problem irritated and haunted him. He gathered facts and data. Then he began to take the data apart, to question it, to separate the real from the false, the facts from the old theory. He began then to see patterns and in regard to absolute and relative motion, velocities.

He kept on questioning himself. What is the velocity of light? If one were to run after a ray of light as it travels, would it no longer move at all? What would happen to some physical situation (Maxwell's equations) if light were not considered constant in velocity? What do I mean when I say that lightning strikes simultaneously at two different points? Would it also be simultaneous if I were moving?

And so the narrowing took place, the analysis and synthesis, for seven years. He then reached the point of saying, what would happen if the velocity of light were constant? Certainly an unconventional question requiring a separation from all past concepts. And the result, for good or bad, is known to all. It certainly changed our lives.

What about the helicopter? After all the data had been analyzed, the difficulty lay in the control of flight. Why? What else could be utilized? What could be adapted from another field (the hinged and adjustable rotors of the autogyro)? It is anyone's guess what could have happened had a systematic approach been used, had the right questions been asked, had we, at an earlier date, divorced ourselves from the idea of a screw-type rotor and rigid wings. Could we have saved ourselves time and effort in military aviation had we asked ourselves: Is a piston necessary? What other method can be used to propel a craft? Can we adopt an idea from another field (the rockets of the 13th century Chinese, the principle of air escaping from a toy balloon)? Try the proposed ideas and draw your own conclusions. Surely, we can invent more efficiently, we can save time, if we will consciously work at it.

If eventually it's going to happen, why not now?

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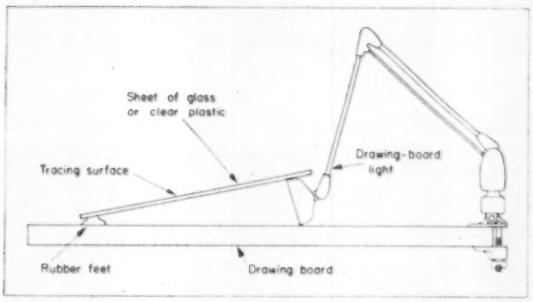
Tips and Techniques

Lighted Tracing Unit

A simple, portable substitute for a lighted tracing box can be devised with a piece of glass and a Dazor-type table lamp. The lamp is brought



down until one edge rests on the table, as shown. A sheet of glass or heavy plastic is placed over the light to form a tracing surface.—DEL BASTON, *Whirlpool Corp., Clyde, Ohio.*

Gear-Center Co-ordinate Tolerances

In dimensioning gear centers it is necessary to work with the center distance, but for fabrication purposes, the actual working dimensions are often given on the drawing in co-ordinates. There are many methods for determining the co-ordinate tolerances. One of the most common is (given the required center-distance tolerance) to pick an arbitrary tolerance on one leg of the triangle and, using the high and low limits of the leg and the center distance, use the Pythagorean Theorem to find the high and low limits of the other leg. Another method is to pick arbitrary, equal tolerances for both co-ordinates.

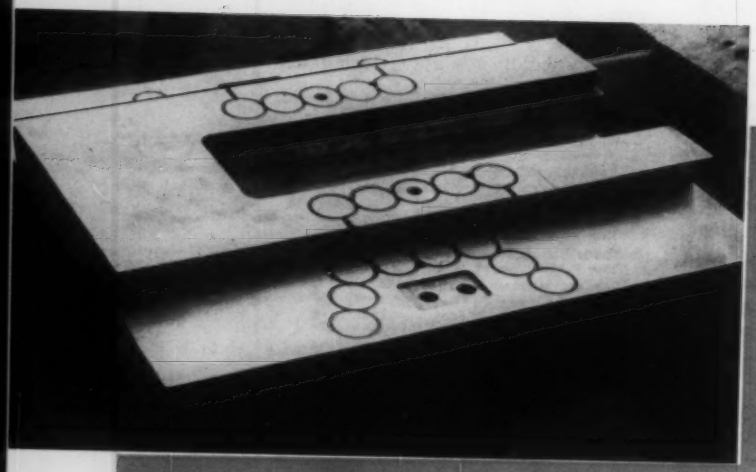
Both of these methods are unsatisfactory. The first method is unsatisfactory because it can result in having a very wide limit for one co-ordinate and a very tight, unrealistic tolerance on the other. The latter method is not satisfactory in systems using precision gears as it gives the center distance a tolerance that can vary in the ratio $\sqrt{2}/1$, depending on the angle that the gear centers make with the dimensioning datum lines.

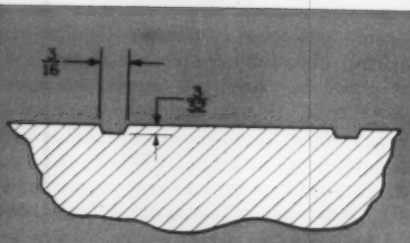
An equation for determining two equal co-ordinate tolerances when the center-distance tolerance is known is

$$\Delta Y = \Delta X = \frac{C(\Delta C)}{(X + Y)}$$

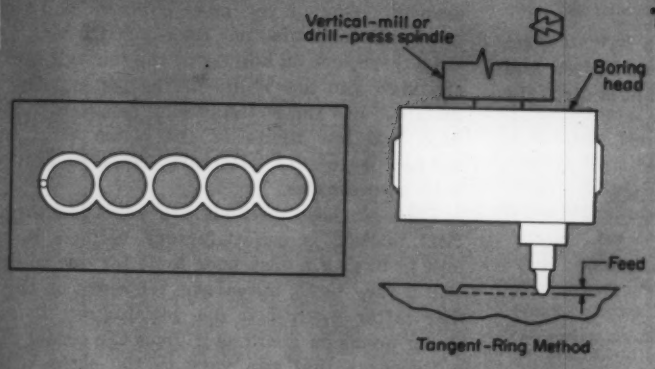
where $\Delta Y = \Delta X$ = co-ordinate tolerance; C = center distance; ΔC = center-distance tolerance; X = X-axis co-ordinate; and Y = Y-axis co-ordinate. This simple equation can be used for any co-ordinates.—SOL ZWIRN, *East Meadow, N. Y.*

scanning the field for *ideas*

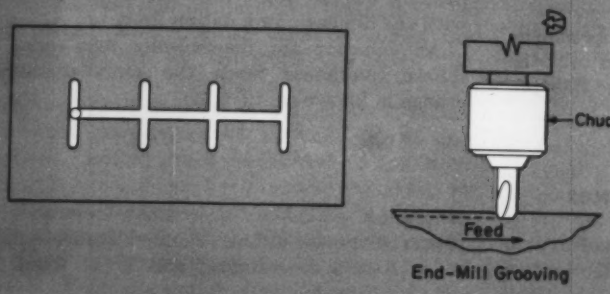




Typical Section

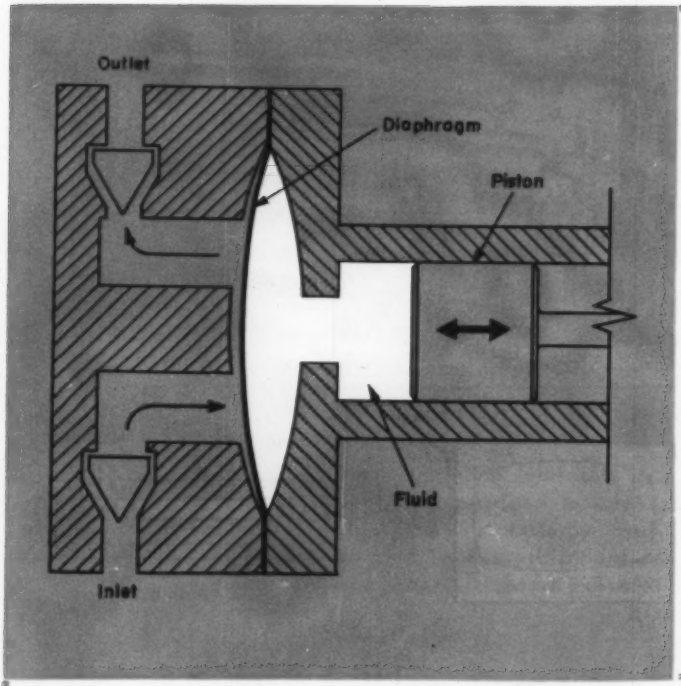


Tangent-Ring Method



End-Mill Grooving

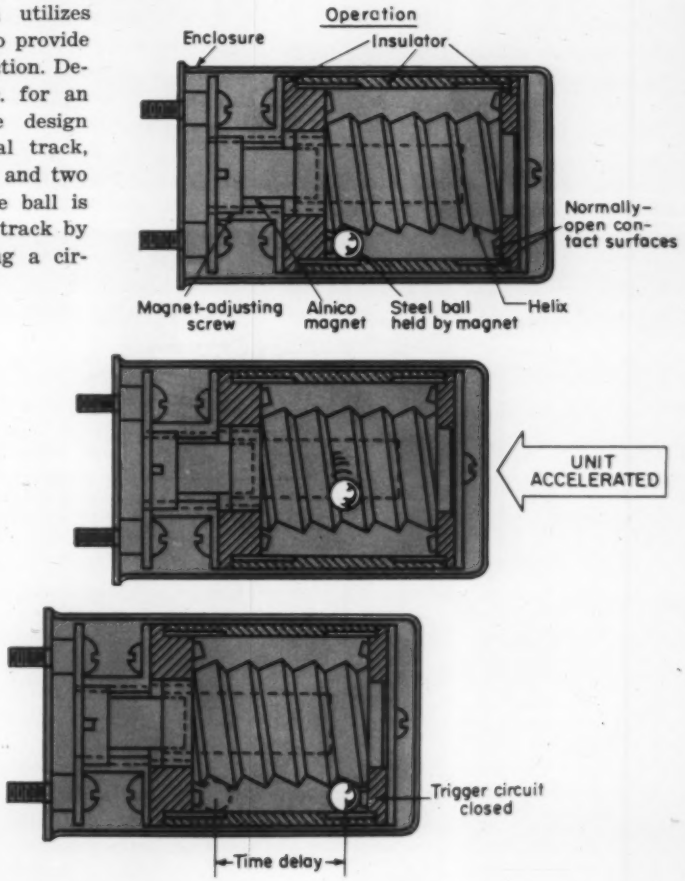
Tangent-ring oil grooves offer a simple, inexpensive solution for lubrication of wear surfaces on sliding members. The grooves are machined by standard facing or boring tools, substantially reducing the time required by hand methods or for milling straight grooves. Diameter, width, and depth of grooves are determined by volume and type of lubrication required. The design was developed by Wickes Machine Tool Div., Wickes Corp.



Fluid linkage between diaphragm and operating piston in a pump minimizes wear of operating parts and provides a balanced - pressure, hydraulic pumping action. In the Kemlon pump designed by Keystone Engineering Co., the pump diaphragm is actuated by a piston that forces fluid against the diaphragm and then retracts to produce a suction stroke. Pulsation of the diaphragm transmits pumping action to the working fluid on the opposite side. The fluid linkage design, which achieves nearly equal pressures on each side of the diaphragm, acts to reduce wear problems common to conventional, mechanical connections.

Pin-ball timing mechanism utilizes rolling ball and helical track to provide controlled delay of switching action. Developed by Safe Lighting Inc. for an inertia-switch application, the design employs a nonmagnetic helical track, a steel ball, a holding magnet, and two sets of contacts. At rest, the ball is held at one end of the helical track by the holding magnet, completing a circuit (normally closed) between one set of contacts.

When the unit is subjected to acceleration or shock, inertia of the ball "disengages" it from the magnetic field and causes it to roll along the track. At the end of the track, the ball completes a normally open circuit to trigger a relay or similar device. Amount of time delay provided by the design is a function of time required for the ball to roll the length of the track under different acceleration rates.



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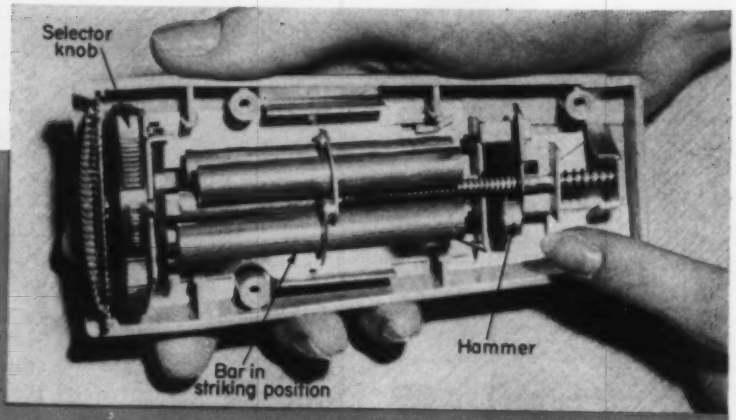
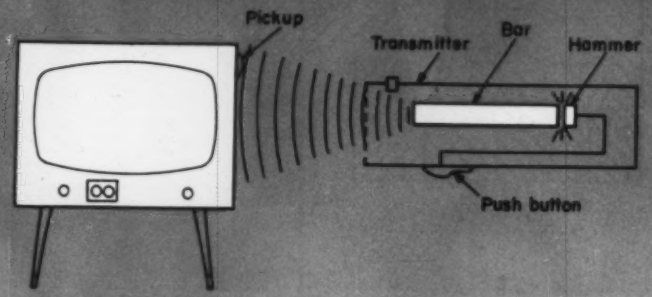
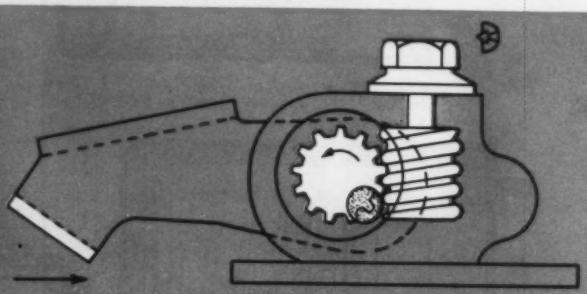
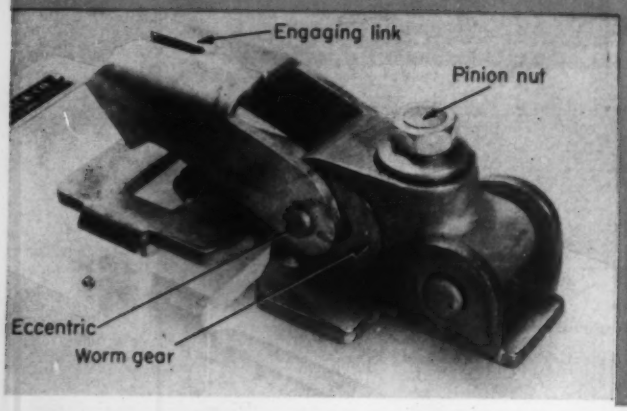




Ultrasonic control system employs all-mechanical "transmitter" for remote operation of electrically controlled devices. Developed by Admiral Corp. for application on television-receiver sets, the transmitter emits signals that are picked up by a microphone, converted into carrier waves, amplified, and then used to provide various control functions.

In the transmitter, four bars of different lengths and resonant frequencies are held in a cage that may be rotated by a four-position selector knob. For each position of the knob, one resonant bar is in position to be struck by a hammer mechanism which is operated manually by a push button. As the push button is moved forward, the hammer is released under spring pressure, striking the bar and emitting a signal corresponding to the function selected on the knob.





Worm-gear locking mechanism provides high clamping pressures in a latch unit developed by Bassick Co. Engaging link of the unit is mounted eccentrically on the worm-gear, which is driven by a manually operated pinion. The mechanism develops high output forces under low-torque input and resists loosening effects of shock and vibration.

By M. H. WEISMAN
Engineering Research Specialist
North American Aviation Inc.
Los Angeles, Calif.

Application of Dry-Film Lubricants *in plain bearings*

Use of dry-film lubricants in plain bearings has up to now been restricted to applications which could not be lubricated satisfactorily with conventional oils and greases. New specifications and performance tests indicate greatly increased possibilities for more extensive use.

DRY-FILM lubricant coatings are a relatively new development in the lubrication field even though their principal ingredients have been in use for many years. Such materials as talc, mica, and powdered graphite have been used as solid lubricants for many applications, either in the form of dry powders or as additives to conventional oils and greases. However, both the dry powder and the additive methods have disadvantages which limit their use.

The major problem with the use of dry powders is that of keeping the lubricating material on the working surfaces where it is needed and providing for continuous replenishment without excessive waste. Use of the powders in oil or grease makes application easier, but uniform dispersion of the powders is not always maintained and this method has limited usage.

Another approach to the problem of applying dry lubricants has been to mix the powders in some form of adhesive or paint-like material. A number of such compositions in the form of graphited lacquers, talc or mica-impregnated paints, etc., have achieved some success in lightly loaded sliding-motion applications. They have not proved satisfactory for highly loaded bearings or wearing surfaces. Either the bonding material becomes tacky and sticky, or it softens and smears when the temperature becomes slightly higher than normal. In many cases, also, the bonding material has poor adhesion and flakes off the bearing surfaces during operation.

Resin-Bonded Dry-Film Lubricants: Answers to problems of adhesion, temperature resistance, load-carrying ability, and uniformity and permanence of application are provided by development of thermosetting resin-bonded dry-film lubricant coatings. These coatings consist of dispersions of one or more powdered lubricating solids, such as graphite, molybdenum disulfide, lead, tin, or silver, in a suitable thermosetting resin. The mixture of solids and resin is applied to the desired area of a part after the area has been given a suitable pretreatment. The coating is then baked at 250 to 400 F to cure the resin. The resulting film, usually less than 0.0005-in. thick, has excellent adhesion to the bearing surface, is dry, nontacky and nonsmearing at temperatures to 250 F or higher, and gives very satisfactory performance as a low-friction wearing surface at high bearing loads.

Lubrication of plain bearings is one of the major potential fields of use for thermosetting resin-bonded dry-film lubricant coatings.

More extensive use of dry-film lubricants has been hindered by lack of a suitable procurement specification for a product of proven quality, and by lack of adequate information concerning per-

formance capabilities of dry-film lubricants. The dry-film lubricant specification MIL-L-25504 prepared by the USAF Materials Laboratory at Wright Air Development Center and recently released appears excellent, and when the Qualified Products List is released, will answer the requirement for a suitable specification.

Testing: To minimize need for actual field testing of bearings and lubricants, a special bearing test machine was designed and built by the North American Aviation Engineering Research Laboratory. This machine can be set up to closely simulate actual service conditions for plain-bearing operation. The conditions can be closely controlled, or can be changed so that the effect of any particular variable, such as coating composition, coating thickness, load, or temperature, can be studied.

The results of tests on this machine have shown excellent correlation to service performance, both for dry-film and conventional lubricants. Therefore, these results can be useful in discussion of the performance capabilities of dry-film lubricants in plain bearings.

Performance: Factors which affect the performance of dry-film lubricant coatings can be discussed under four major headings:

1. Coating quality
2. Bearing design
3. Handling and assembly factors
4. Service conditions

Coating Quality: Dry-film lubricant coating quality and service performance are a function of pretreatment of the surface to be coated, coating application processing procedure, curing treatment, composition of coating, and coating thickness. All these factors are important but they will be touched upon only briefly in this discussion. Detailed discussion of these factors may be found elsewhere.[1,2]

In general, surface pretreatments, coating application procedures, and curing treatments recommended by the major dry-film lubricant producers have proved to be satisfactory. Suitable surface treatments for more common materials are phosphate treatment, such as Lubrite, for carbon and low-alloy steels, sulfuric or chromic-acid anodizing for aluminum alloys, and grit blast with 120 mesh Alundum or silica grit for hard chromium and hard nickel-plated surfaces. Preferred application method for dry-film lubricant coating is spraying, but brushing and dipping may also be used. Curing treatments of 1 hr at 300 F for aluminum alloys and 1 hr at 375 to 400 F for steels are generally recommended.

Composition of the dry-film lubricant coating has an effect on performance. A particular coating formulation may give excellent performance in one type of installation and poor performance in another where operating conditions are greatly different.

Thickness of dry-film lubricant coatings was found to have a significant effect on performance. Relation of wear life to coating thickness is shown in Fig. 1. Test conditions were 35-deg angle of oscillation under a bearing load of 39,000 psi, direction of load application being reversed each half-cycle of operation. Dry-film lubricant coating was applied to both rubbing surfaces, that of a hard-chromium-plated steel shaft and the bore of a plain spherical bearing. Thickness range for satisfactory performance, which was specified as 20,000 cycles of operations, was between 0.0002 and 0.00045 in., with optimum performance in the thickness range 0.00025 to 0.00035 in.

Bearing Design: Design of parts to be used with dry-film lubricants has a pronounced effect on the lubricant performance. Parts to be used with dry-film lubricants must be designed for their use. Dry-film lubricants cannot be added later as an afterthought without often entailing considerable difficulty.

Dry-film lubricant coatings may be described as lubricating paints. Like all paints, they can be easily scraped off or abraded by rough surfaces and sharp cutting edges. Therefore, surfaces which will move in contact with dry-film lubricants must be smooth and their edges must be well rounded.

In the case of mating parts, such as a plain bearing and shaft, sufficient clearance must be pro-

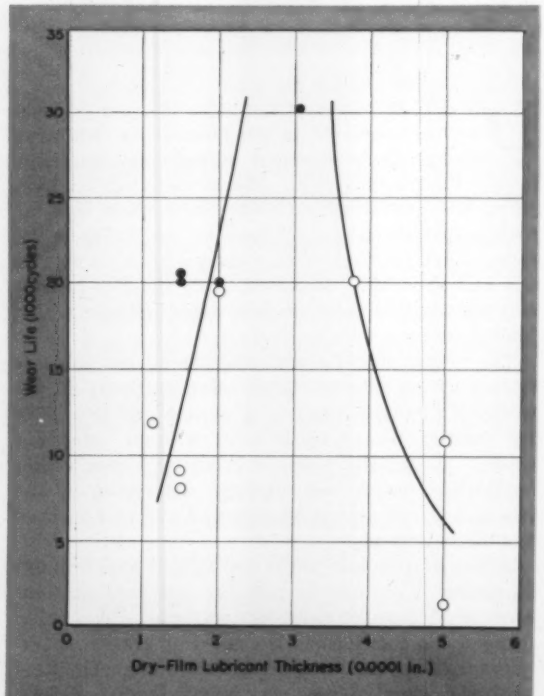


Fig. 1—Effect of thickness of dry-film lubricant coating on wear life of oscillating-motion plain bearings. Bearing load for test was 39,000 psi, and oscillation angle was 35 deg. Dry-film lubricant was applied to rubbing surfaces of shaft and bearing. Solid dots indicate no failure of dry-film lubricant at end of test.

[1]References are tabulated at end of article.

vided to permit assembly without scraping off or otherwise damaging the dry-film lubricant coating. Clearance is also necessary to permit the wear debris to work its way out of the bearing without causing the bearing to bind.

Use of dry-film lubricant coating on both the shaft OD and bearing ID of an oscillating-motion plain-bearing installation will increase the wear-life performance two to three times over that obtained if only one of the rubbing surfaces is coated.

Handling and Assembly Factors: Dry-film lubricant coated parts must be stored, handled and assembled carefully to prevent the coated surfaces from being damaged or contaminated with dirt, oil, grease, etc. If the dry-film lubricant coating has been abraded, scored or otherwise damaged, the parts must be rejected because the currently used bonded-resin type coatings cannot be repaired satisfactorily in the field.

Service Conditions: Service conditions which most seriously affect the wear-life performance of dry-film lubricant coatings are presence of contaminants, load, operational cycle, and temperature.

Effect of Contaminants: The presence of most contaminants will drastically reduce the wear-life performance of dry-film lubricant coatings. Oil or grease on exposed surfaces will permit dirt to adhere and inflict damage.

Oils and greases on dry-film lubricant coated surfaces have another adverse effect. Even though a dry-film lubricant coated panel may not show any deterioration after immersion for as long as a week in an oil or grease, the coating cannot be considered to have satisfactory resistance to oil or grease. When the bearing is operated under load, the presence of oil or grease will cause very rapid failure of dry-film lubricant coatings. There are several possible explanations for this. The oil may have a solvent action which softens the resin binder, or the oil may be forced through the thin and relatively porous dry-film lubricant coating by the load pressure and destroy the bond of the film to the pretreated surface. In either event, after a short period of operation the coating appears to have been wiped off the loaded rubbing surfaces and galling begins.

Water as a surface contaminant does not appear to damage properly cured dry-film lubricant coatings. But, in certain low-operating-force mechanisms where extra power to start is not available, or where the operation is infrequent, the presence of even a few drops of liquid water will form ice under extreme cold conditions, freezing the contacting surfaces together and preventing motion. Silicone oils used on the surfaces as a water repellent have been satisfactory when the moisture resulted only from normal atmospheric condensation, but proved ineffective in the presence of larger amounts of water such as could be introduced during washing or a rainstorm.

Effect of Load: Magnitude of the bearing load influences both the coefficient of friction and the wear life of dry-film lubricants. Effect of load on the coefficient of sliding friction as determined by tests on a sliding-friction machine built by North American Aviation Research Laboratory is shown in Fig. 2. The flat ends of steel rods were os-

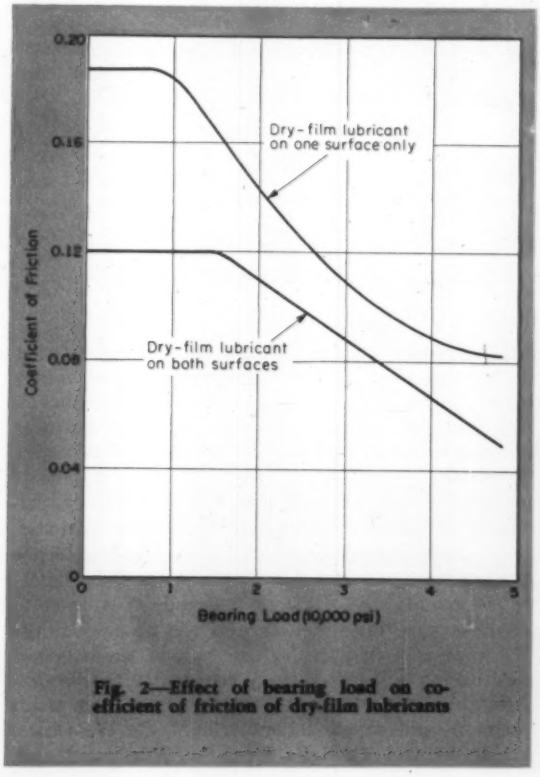


Fig. 2—Effect of bearing load on coefficient of friction of dry-film lubricants

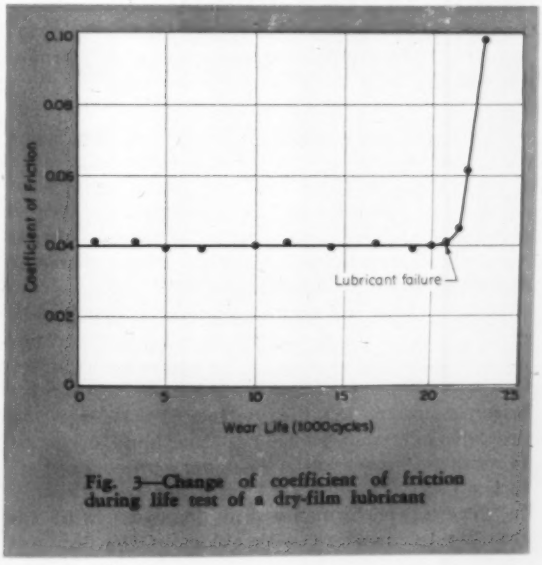


Fig. 3—Change of coefficient of friction during life test of a dry-film lubricant

cillated back and forth across a flat steel plate.

Tests represented by the upper curve in Fig. 2 were conducted with the dry-film lubricant coating on the flat plate only; the lower curve shows results when both the ends of the rods and the surface of the flat plate were coated. When both rubbing surfaces were coated, the coefficient of sliding friction remained constant at 0.12 up to a bearing pressure of about 15,000 psi, then decreased with increasing load to 0.05 at 48,000 psi. These results have been confirmed by other tests, with coefficient of sliding friction as low as 0.03 at loads of 100,000 psi. Life tests have shown that the coefficient of friction remains constant until failure begins, as shown in Fig. 3, which is typical of the results of many tests.

Wear life of dry-film lubricants decreases with increasing load. As would be expected, all coatings have a finite life at the very high loads, while at low loads some dry-film lubricant coatings appear to last indefinitely.

Effect of Operational Cycle: Properly applied, good quality dry-film lubricant coatings gradually wear thin until high points of the underlying base material are exposed, causing failure by galling due to welding of the base-metal surfaces. Dry-film lubricants appear to exhibit a rather constant rate of wear at a given load, life of the coating being determined by length of travel of one rubbing surface over the contacting area of the other. Increase of the angle through which the bearing or shaft is oscillated will cause a proportional reduction in the life of the dry-film lubricant coating. Similarly, if the bearing is operated under a constant unidirectional load instead of having the load reversed each half-cycle of oscillation, bearing life will be cut in half.

Some investigators have reported that the speed of motion can affect performance of dry-film lubricants. All of the tests described here have been conducted at slow speeds of from 0.20 to 0.75 sfpm. No speed effect would be expected in this range, nor has any been observed in these tests.

Effect of Temperature: Resins of the types which can be used as binders in dry-film lubricants differ widely in their low and high-temperature properties. Users should perform extensive service or simulated service testing to determine actual performance capabilities at various temperatures of individual dry-film lubricants.

Results from the limited number of such tests reported up to the present time indicate that temperatures as low as − 65 F do not seem to affect the performance of thermosetting-resin dry-film lubricants, except for the matter of ice formation previously discussed. On the other hand, exposure to elevated temperatures has a very pronounced effect on dry-film lubricant wear-life performance. In general, performance life decreases with increasing temperature, with extent of the decrease depending principally on temperature resistance of the resin or other type binder used to hold the lubricating additives on the wear surfaces.

There are considerable variations in elevated-temperature performance among currently available dry-film lubricants. For example, in one set of tests, coated parts were exposed to 500 F for varying lengths of time, then tested at room temperature. Exposure times up to 50 hours had no apparent detrimental effect, but a 100-hour exposure to 500 F reduced the subsequent room-temperature wear life by one-half. In another test where the coated parts were tested at 500 F at a loading of 25,000 psi, one coating had a wear life only one-fifth as long as the normal room-temperature wear life, and the 500 F performance of other coatings was even poorer.

Summary: The following conclusions can be drawn from this discussion concerning performance and use of dry-film lubricants in plain bearings:

1. To achieve maximum performance and long life, dry-film lubricants must be of good quality, properly applied, and the coated parts must be carefully handled during storage and installation.
2. Plain-bearing installations to use dry-film lubricants must be designed to permit proper application of the required pretreatments and to allow for necessary clearances.
3. At operating temperatures of less than 250 F, dry-film lubricated plain bearings can operate for thousands of cycles at loads of 40,000 psi and higher.
4. Wear-life performance of dry-film lubricants is seriously reduced if they are subject to contamination or elevated temperatures.

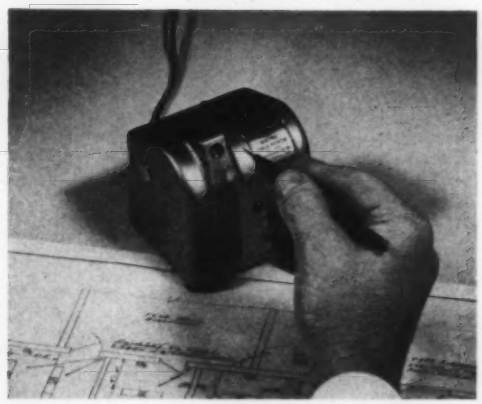
Use of dry-film lubricants will be aided by release of a suitable procurement specification and continued improvement of available types.

REFERENCES

1. R. E. Crump—"Solid Film Lubricants," *Instruments and Automation*, Vol. 29, No. 11, November, 1956.
2. R. E. Crump—"Recent Developments in Solid Film Lubricants," ANI Conference Paper, November, 1956.

"The patent system does in this free enterprise system assure small business an equality of opportunity in the competition for the free market, and with its greater flexibility, small business can better take advantage of the incentives which the patent system affords. This is not to disparage the noteworthy accomplishments by the large research facilities of government and big business. Only such institutions can afford the activities in pure research and future problems that underlie the technology of the next decade. Yet, in spite of these superior facilities and the broader range of interests to which the research of these larger institutions is directed, very frequently the 'breakthrough', the startling innovation, comes from small business and small laboratories."—C. W. OOMS, *patent counsel, La Salle Steel Co., Hammond, Ind.*

Magnetic Wheel Holds Abrasive Disc In Automatic Pencil Pointer

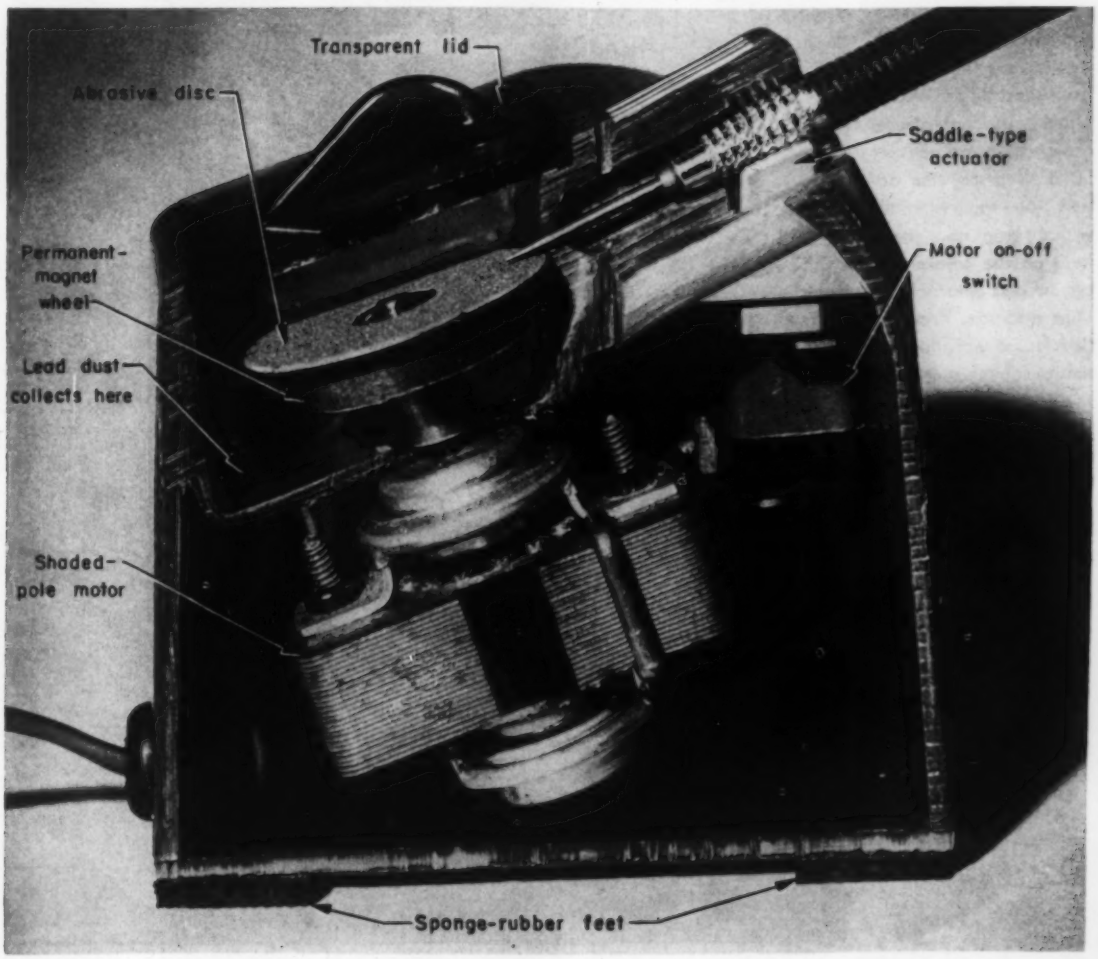


AUTOMATIC STARTING of drive motor in a new electric pencil pointer is accomplished by simply inserting the pencil. Designed by Robert P. Johnson, Johnson Mfg. Co. Inc., Monroeville, Ind., the Point-O-Matic is suitable for pointing leads in standard lead holders or wooden pencils.

When the lead holder is inserted in the machine, it pushes down a saddle-like plunger which actuates the motor on-off switch.

QUICK ATTACHMENT AND REMOVAL of the abrasive disc is permitted by a permanent-magnet type mounting wheel. The disc can be removed by lifting it with the end of a pencil.

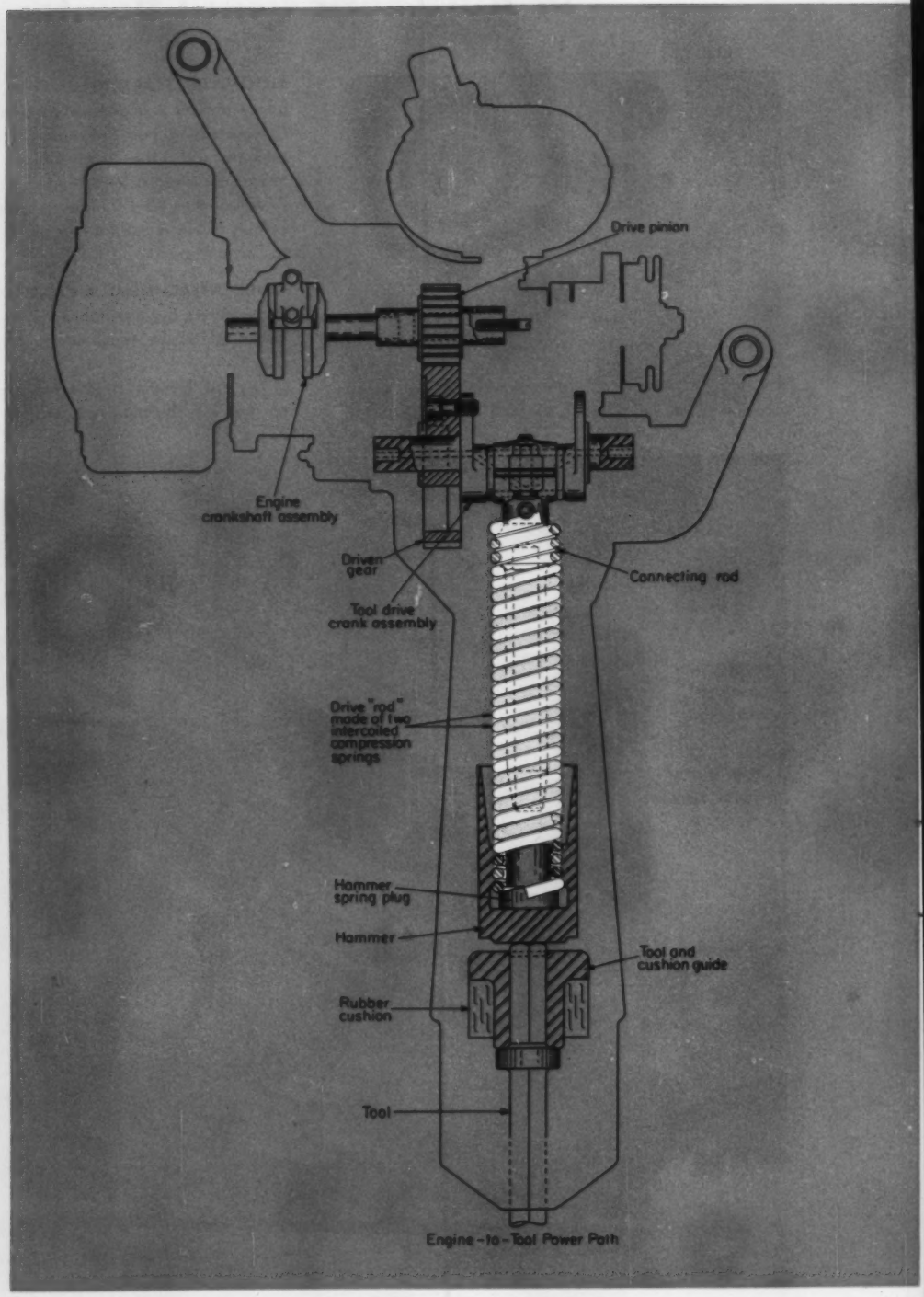
The lid on the lead-waste compartment is transparent so that the sharpening operation can be watched.



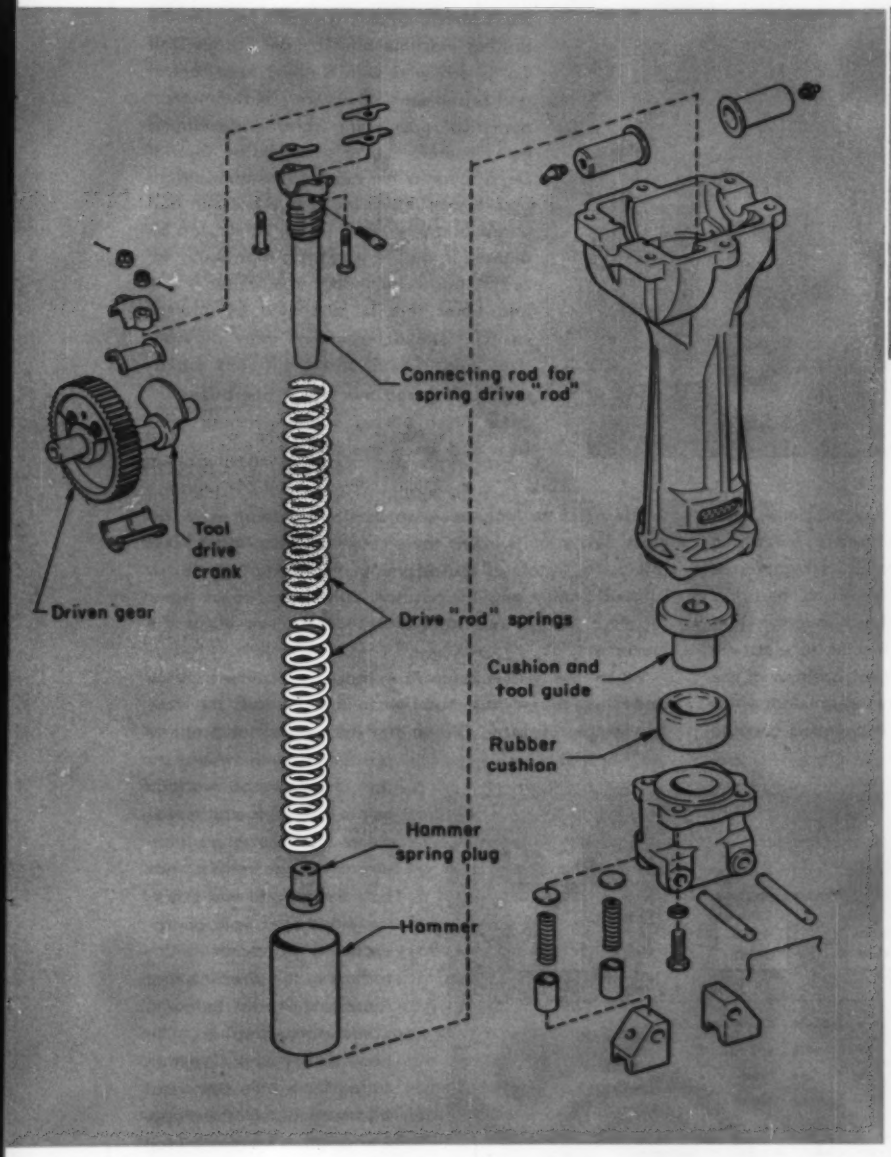
Drive "Rod" Made of Springs

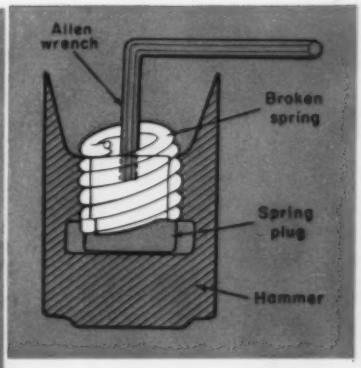
NEW DRIVING PRINCIPLE used in the design, develops the high-velocity hammer blows as follows: When the crankshaft is in the upward half of the operating cycle, it lifts the hammer with dual intercoiled springs shown in color cutout. Momentum of the hammer at the top of the crankshaft cycle compresses the springs. This compression energy, which is increased by the downward drive of the crankshaft, shoots the hammer downward with tremendous thrust, delivering a high-velocity blow. The intercoiled compression springs set up a sling-shot-like action of the hammer without creating a shock load on the crankshaft, engine and operator.

In addition, this unit develops a vibration action in combination with the hammer blows

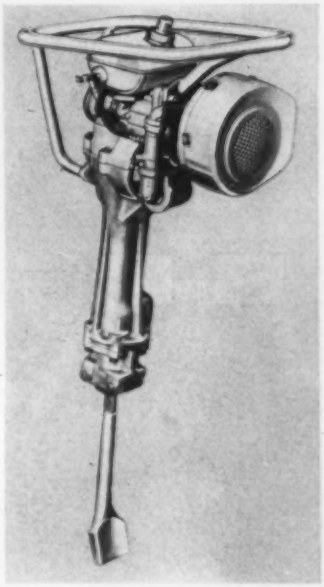


Shock-Cushions Power Hammer



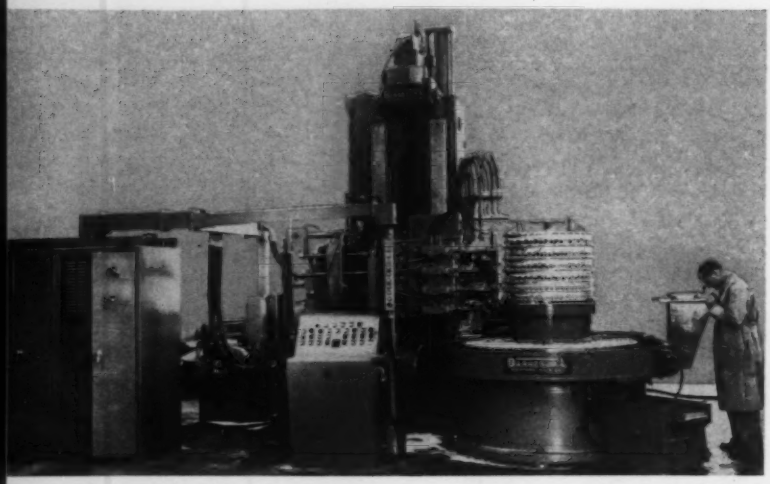


IN ASSEMBLY, the two compression springs are first intercoiled. Then one end is screwed into a threaded hole in the hammer and the other over threads on the connecting rod. If the springs should happen to break off in the hammer spring plug, the assembly is designed to permit an Allen wrench to unscrew both the plug and the springs.



HIGH-VELOCITY BLOWS in a new power hammer design are produced with a low shock load to machine and operator. By a unique spring and crank assembly construction, shock load is practically balanced out in a tool designed by the Racine Hydraulics and Machinery Inc. The machine furnishes 1500 blows per minute and is operated by a 1¼-hp, two-cycle, gasoline engine.

Tape-Controlled Positioner Designed with

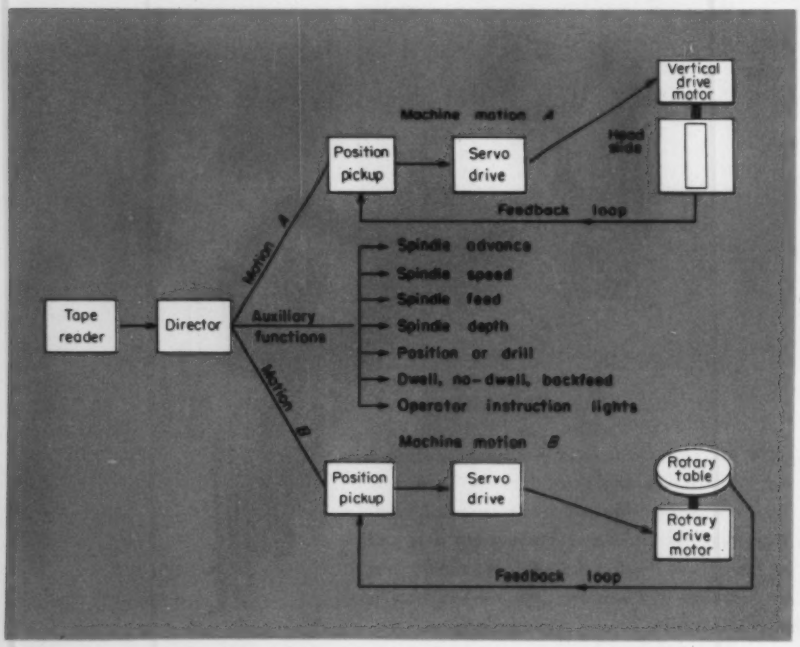


AUTOMATIC OPERATION of a four-spindle drilling machine built by the Barnes Drill Co. is achieved with a novel tape control and selsyn sensing system. A two-motion numerical positioning control, developed by General Electric's Specialty Control Dept., permits the machine to maintain an accuracy of 0.005 in. of true position and a repeatability of ± 0.001 in. It can be aligned in all planes to less than 0.001 in.

This particular machine is set up to put 248 holes into a jet-engine compressor casing. The holes are of three different sizes and require three different operations. Required machining operations include finish boring and generating front face and back counterbore.

NUMERICAL INFORMATION from the punched paper tape is fed from the tape reader to the director portion of the positioning control where information is segregated into three main categories and delivered to their respective destinations. For example, the numerical data for motion A are converted in the director to electrical voltages representing the desired vertical position of the machine slide and fed to the position pickup unit which is mounted on the machine. The pickup unit is coupled to the machine lead screw so that as the lead screw rotates, selsyn units inside the pickup unit also rotate. This allows the rotors of the selsyns in the pickup unit to assume a distinct angular position with respect to its stator for each 0.001 in. throughout the total travel of the machine.

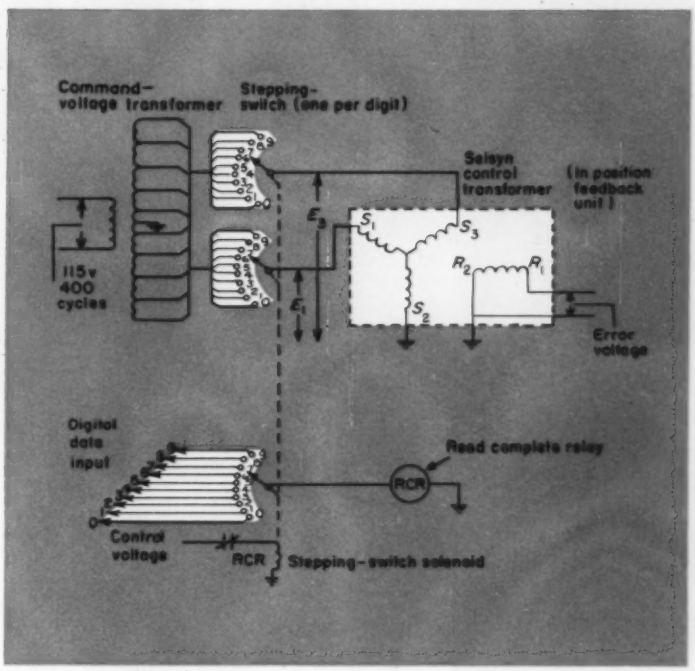
When the selsyn rotors are properly positioned with respect to the voltage applied to their stators, the voltage output is zero. When the rotors are not properly positioned with respect to the tape-control voltage applied to their stators, the rotors produce a position-error voltage which has both magnitude and polarity. This error voltage operates a dc motor which rotates in the direction that reduces the error below a predetermined value. The head is then in the position called for by the numerical information on the tape. The position feedback loop has an electrical accuracy equivalent to ± 0.0005 in.



Cascaded Selsyns for Feedback Accuracy

ELECTRICAL CONTROL SIGNALS are supplied to the director by closures of switches or relays which represent the numerical-information digits supplied by the data input. There are several feedback selsyns in the position pickup units. A single selsyn is used to represent each digit in the position number on the tape, except for the two least digits. For example, the digits 1 and 5 in the position number 20.015, are represented by one selsyn.

Each selsyn except one is positioned to one of ten possible positions spaced at 36 deg intervals. The last selsyn is positioned to one part in 100 or 3.6 deg. The reference or director command voltage for a particular digit, for example, 7, is simply a voltage varying in magnitude and polarity which could be obtained from a selsyn generator with rotor positioned to 0.7 of a revolution.



Discrete director command voltages in this control system are actually obtained from a tapped transformer instead of a selsyn generator. To select the desired taps on the transformer, solenoid-operated stepping switches are used. When the correct digit position is reached, as determined from the input data, the stepping switch stops its search and at the same time connects the correct transformer taps into a given selsyn. This action is accomplished by having more than one contact bank on the stepping switch.

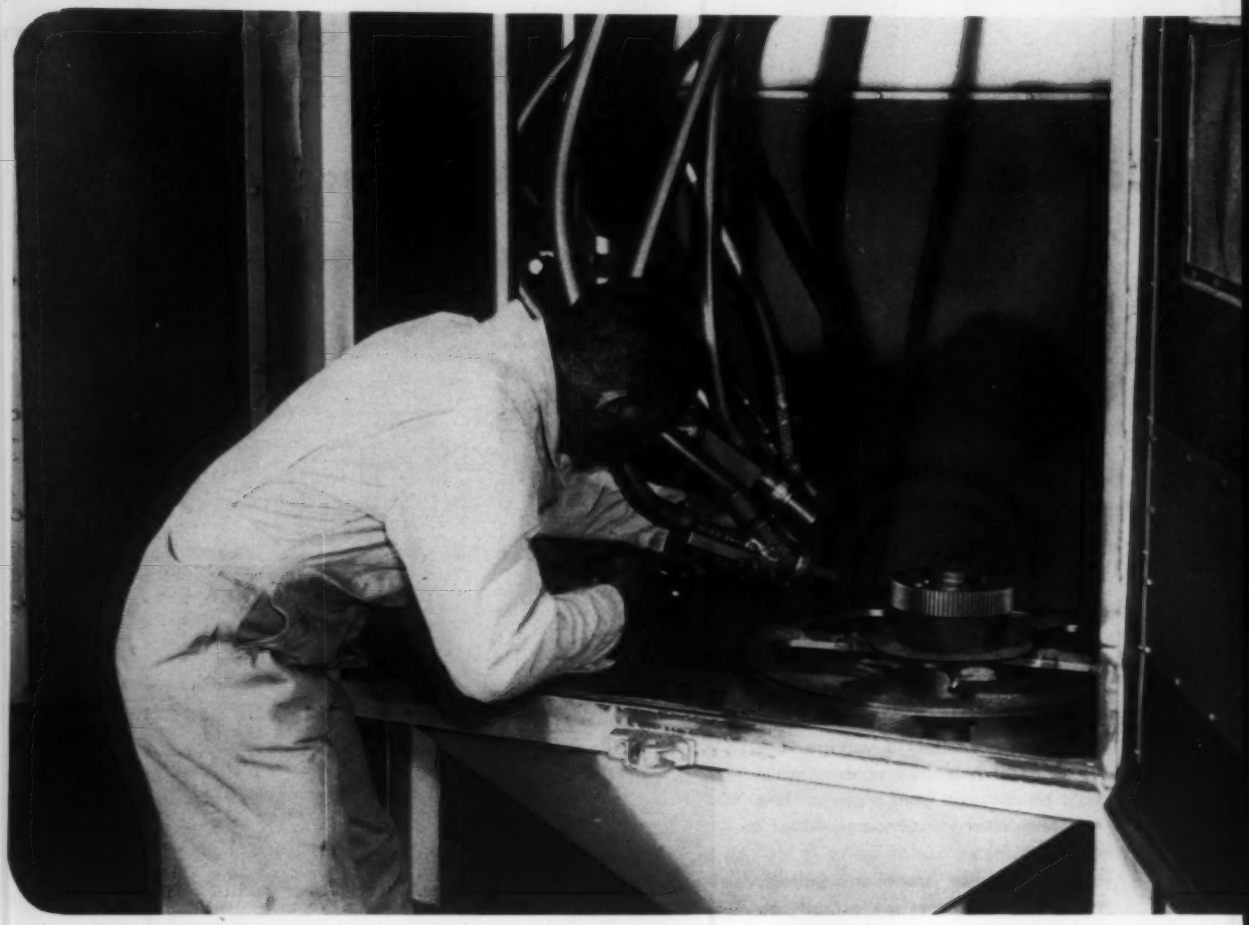
Each digit of numerical information is represented by a stepping switch to supply information to the selsyns to position to 0.1 revolution. The position pickup unit combines all selsyns, and gears them to the machine motion. Since each feedback selsyn is matched by a command voltage representing a definite decimal part of a number, the position of each feedback selsyn must represent decimal lengths of machine motion.

It is also necesary that a 10 to 1 ratio be maintained between successive selsyns. For example, the lowest speed selsyn for a travel of 450 in. would be geared for one complete revolution per 1000 in. of machine travel and would be controlled by the digit representing hundreds; the second selsyn, one revolution per 100 in. controlled by the tens digit; the third selsyn, one revolution per 10 in. controlled by the units digit; and the fourth selsyn, one revolution per in. controlled by digits representing the tenths and hundredths.

For the system to position to 0.01 revolution, an interpolating voltage of 0.1 magnitude is introduced to each selsyn from the next lower digit. For example, the hundredths-digit stepping switch introduces a voltage through a 10-to-1 stepdown transformer to the selsyn geared for one revolution per in., while the tenths digit stepping switch introduces a voltage directly from the tapped transformer to that selsyn.

If the rotor of each feedback selsyn is not positioned to the portion of a revolution represented by the command voltage, an error voltage will be sent back from each selsyn. The various selsyn signals are combined in a mixer to produce a single signal having the correct sense, indicating the direction of error, and an amplitude proportional to displacement from the correct position. A specially designed mixer circuit provides a smooth takeover from the coarse selsyn units to the fine selsyn unit.

The error signal from the mixing circuit is a 400-cycle, single-phase signal since the selsyns are excited from 400-cycle, single-phase power from a small motor-generator set in the control panel. This signal is amplified and amplitude discriminated which results in a dc signal of magnitude and polarity determined by the amount and direction of the error. This signal is used to control the servo drive to position the machine.



Shot Peening

Designer's guide to the process, its applications.

DEVELOPED in the late twenties, shot peening was discovered by accident. A small batch of automobile valve springs behaved much better than expected under test. Investigation revealed that they had been shot blasted to improve the surface. This discovery led to commercial development of the process, although up to the start of the second world war the process was confined almost exclusively to automotive parts such as springs, gears, and axles. During the war, pressing need for higher performance without increased weight caused rapid development of the shot-peening process.

Today in the automotive industry, all chassis and valve springs, and many gears and shafts, are shot peened. Without shot peening, these parts would have to be 30 to 50 per cent heavier, increasing the weight of an automobile by as much as several hundred pounds. The weight savings made possible by use of shot-peened parts are of great importance in the aircraft industry for engine parts, propellers, landing gear, and similar items subject to repeated loading. Other industries requiring a high strength to weight ratio, such as the oil industry, also rely heavily on shot peening. An important recent development is shot peening of ultrahigh-strength steels for improved fatigue-life characteristics.

In its initial stages, shot peening was a more or less haphazard variation of shot blasting. It has

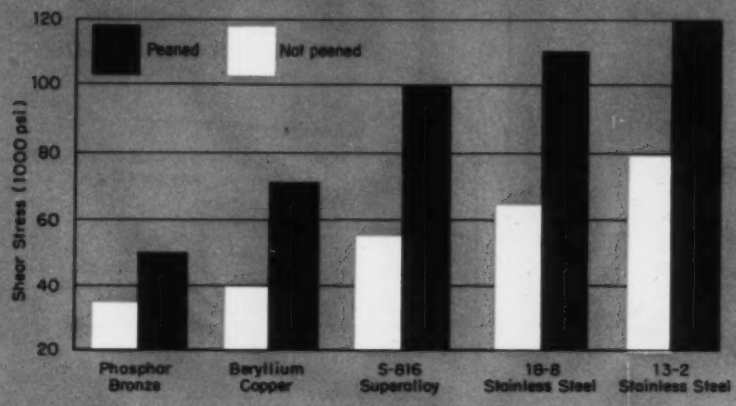


Fig. 1 — Safe fatigue-life ranges for coil springs of various materials, indicating increased life available with shot peening

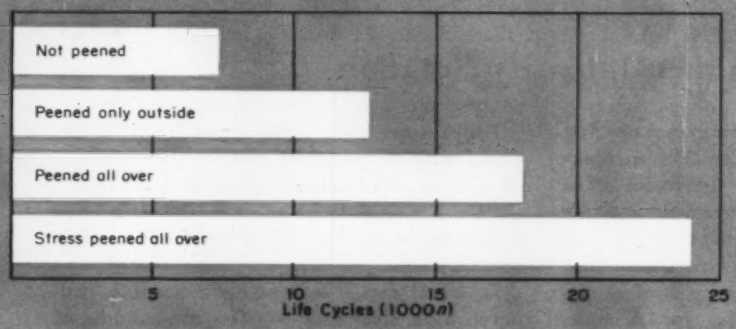


Fig. 2—Effect of different shot-peening treatments on fatigue life of latch springs

By H. O. FUCHS and E. R. HUTCHINSON
Metal Improvement Co.
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its effects, and how and where to specify it.

now become exact, making it possible to issue standard specifications and obtain repeatable results.

Fatigue-Life Improvement

Principal use of shot peening is to increase fatigue life of cyclically stressed parts. The earliest application (and still largest in terms of volume) is spring treatment. Favorable results are obtained on coil springs in a great variety of materials. Fatigue-strength increase of 70 to 150 per cent can be expected from nonferrous or high-alloy spring materials, Fig. 1; for steel springs, increases of over 70 per cent have been reported.[1] Leaf springs were among the early applications and considerable data are available.

Full improvement in spring life is obtained after a peening treatment of 2 minutes; further peening, up to 20 minutes, does not further improve the fatigue life. More significant improvements are obtained by peening springs while they are held in the strained or loaded position. For example, an actual improvement quoted (compared to a 5000-cycle life of an untreated spring) is 100,000 cycles for a peened spring and up to 1 million

[1]References are tabulated at end of article.

Shot Peening

Designer's guide to the process, its applications.

DEVELOPED in the late twenties, shot peening was discovered by accident. A small batch of automobile valve springs behaved much better than expected under test. Investigation revealed that they had been shot blasted to improve the surface. This discovery led to commercial development of the process, although up to the start of the second world war the process was confined almost exclusively to automotive parts such as springs, gears, and axles. During the war, pressing need for higher performance without increased weight caused rapid development of the shot-peening process.

Today in the automotive industry, all chassis and valve springs, and many gears and shafts, are shot peened. Without shot peening, these parts would have to be 30 to 50 per cent heavier, increasing the weight of an automobile by as much as several hundred pounds. The weight savings made possible by use of shot-peened parts are of great importance in the aircraft industry for engine parts, propellers, landing gear, and similar items subject to repeated loading. Other industries requiring a high strength to weight ratio, such as the oil industry, also rely heavily on shot peening. An important recent development is shot peening of ultrahigh-strength steels for improved fatigue-life characteristics.

In its initial stages, shot peening was a more or less haphazard variation of shot blasting. It has

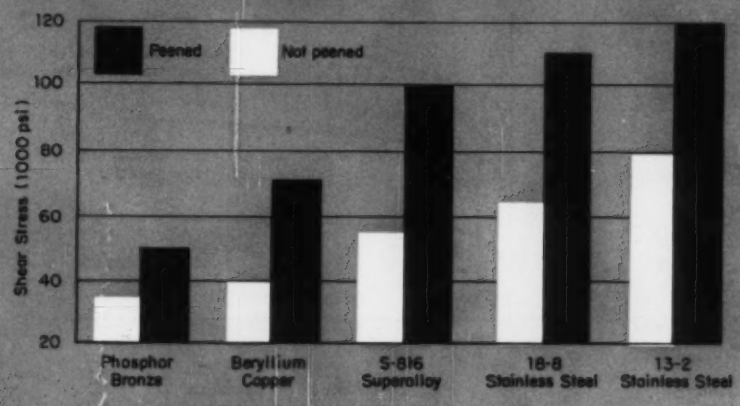

Fig. 1 — Safe fatigue-life ranges for coil springs of various materials, indicating increased life available with shot peening

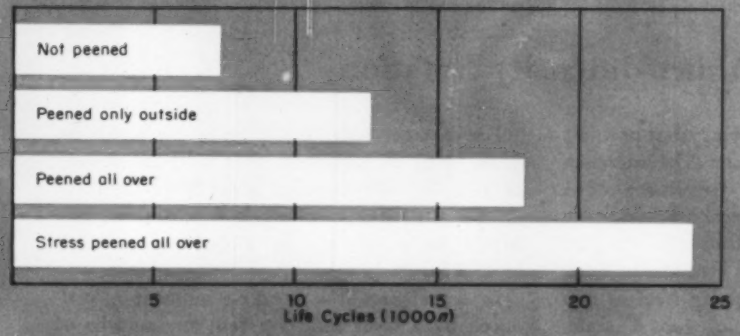

Fig. 2—Effect of different shot-peening treatments on fatigue life of leaf springs

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Los Angeles, Calif.

its effects, and how and where to specify it.

now become exact, making it possible to issue standard specifications and obtain repeatable results.

Fatigue-Life Improvement

Principal use of shot peening is to increase fatigue life of cyclically stressed parts. The earliest application (and still largest in terms of volume) is spring treatment. Favorable results are obtained on coil springs in a great variety of materials. Fatigue-strength increase of 70 to 150 per cent can be expected from nonferrous or high-alloy spring materials, Fig. 1; for steel springs, increases of over 70 per cent have been reported.[1] Leaf springs were among the early applications and considerable data are available.

Full improvement in spring life is obtained after a peening treatment of 2 minutes; further peening, up to 20 minutes, does not further improve the fatigue life. More significant improvements are obtained by peening springs while they are held in the strained or loaded position. For example, an actual improvement quoted (compared to a 5000-cycle life of an untreated spring) is 100,000 cycles for a peened spring and up to 1 million

[1]References are tabulated at end of article.

Fig. A — Almen peening-intensity gages checking curvature of unpeened (left) and peened (right) strips.

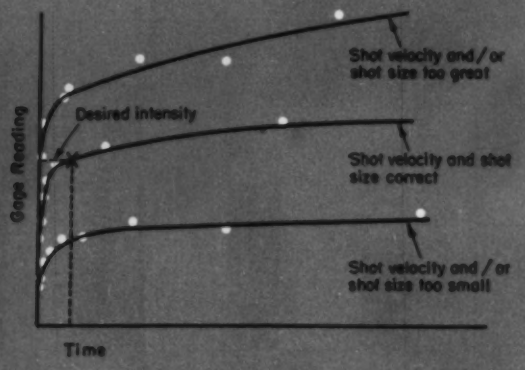

Gage Reading
Time
Desired intensity
Shot velocity and / or shot size too great
Shot velocity and shot size correct
Shot velocity and / or shot size too small

Fig. B—Increase of curvature of Almen test strip with increase in peening time.

Almen-Intensity Notation

Standard method of specifying shot-peening intensity is by Almen numbers. The numbers indicate the arc height (or curvature) of a steel strip which has been exposed on one side to the same shot-peening treatment as the part for which the treatment is specified. Such strips, Fig. A, are made of spring steel in two standard thicknesses—0.051 in. for A scale, 0.094 in. for C scale. Their standard hardness is Rockwell C 47±3.

Specification of an Almen intensity always implies that peening must be carried out to saturation. The arc height increases with time of peening up to a limiting value, Fig. B. The same arc height obtained by a shorter time of potentially more intense peening corresponds to a spotty distribution of residual stresses and to less increase in fatigue life.

Curvature of the test strip is used to measure intensity of the shot stream. In a peened strip, when b is the arc height in in. and c is the chord length in in., the bending moment, M, can be obtained by $M = 8EIb/c^2$ in.-lb, E and I being the modulus of elasticity and the moment of inertia of the section.

For a steel strip 0.075 wide by 0.051 in. thick, with b measured over a chord length of 1.25 in., this equation gives M as 1270 in.-lb; for a typical value of b = 0.014 in., this would be equivalent to a bending moment of 17.8 in.-lb.

In actual fact, the bending moment is produced by a layer that is a few thousandths of an inch in thickness, but to obtain some idea of the forces involved, the force F, the resultant of the residual stress, is considered to be concentrated on the surface. Then, $F = 2M/t$, where t is the thickness. In the example given, and converted to a strip-width of 1 in., F = 935 lb/in. Generally, for a deflection b of the test strip, the surface force per inch of width is $F = 66{,}000b$ lb.

Table 1—Recommended Peening Intensity for Steel

Thickness (in.)	Almen Intensity (A Scale)
$\frac{1}{32}$ to $\frac{1}{16}$	0.003 to 0.009
$\frac{1}{16}$ to $\frac{1}{8}$	0.007 to 0.014
over $\frac{1}{8}$	0.012 minimum

cycles for a strain-peened spring.[2]

Localized peening may merely shift location of failure, as shown by a series of tests on a C-shaped spring, Fig. 2.[3] Unpeened springs failed on the outside. When peened on the outside, they failed on the inside; peening all over resulted in increased life.

Spring life improvement is particularly important for aircraft springs. In one instance, replacement of an unpeened spring by a stress-peened spring resulted in a weight saving of over 40 lb, achieved by reduction in size of the spring and supporting parts.[4]

In addition to springs, many parts subject to

alternating stresses, particularly on aircraft equipment, are shot peened. Exhaust stacks, Fig. 3, have an odd shape and are thin material, yet improvement gained by shot peening is maintained even at working temperatures. Piston wrist pins are shot peened on the inside by special nozzles. Peening of axle shafts, Fig. 4, increases the endurance limit more than 100 per cent.[5] Cold straightening is very damaging to the fatigue life, so shot peening is used to overcome these harmful effects.

Peening Hard Steel

Very interesting results are achieved by peening hard steel, Fig. 5. Without peening, fatigue strength reaches approximately 70,000 psi max at about Rockwell C 42 hardness.[6] Fatigue strength of unpeened parts does not increase with increasing hardness, while fatigue strength of peened parts increases proportionately with hardness up to 140,000 psi at Rockwell C 53.[6,7] By using shot-peened hard steels, the designer can achieve greater static and fatigue strengths without danger of brittleness.

Surface decarburization is a danger when using high-strength steel parts. Loss of fatigue strength, following even partial decarburization, is well known. Restoration of lost fatigue strength by shot peening is very effective. Up to 0.040 in. depth of partial decarburization on ultrahigh-strength steel for landing gears is rendered harmless by shot peening, Fig 6. Mozley states, "It appears safer to permit some decarburization and peen the part, rather than risk surface carburization".[8] Further results are given by some fatigue tests on very hard springs, quenched to a hardness of Rockwell C 62 and not drawn, Fig. 7. Without peening, these springs had a very low fatigue life; with peening they lasted longer than peened springs of the highest commercial hardness.[9]

SHOT PEENING

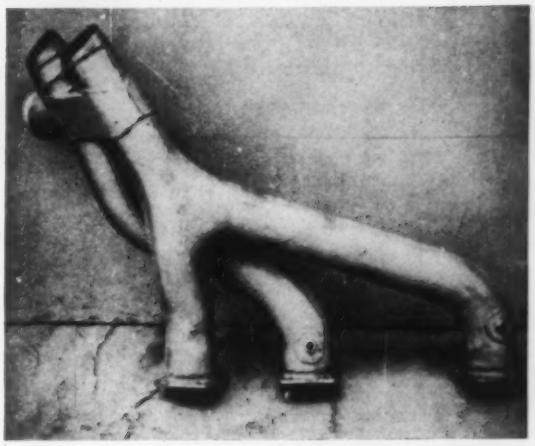


Fig. 3—Aircraft-engine exhaust stack, shot peened for improvement of fatigue life under alternating stresses at elevated temperatures

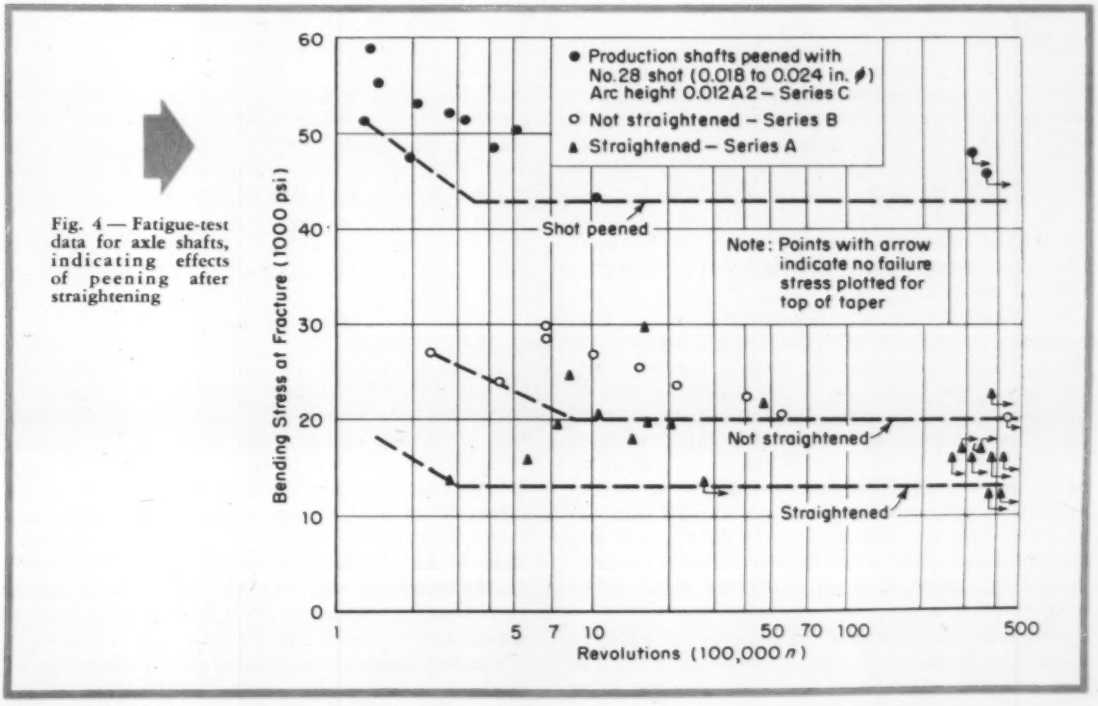


Fig. 4 — Fatigue-test data for axle shafts, indicating effects of peening after straightening

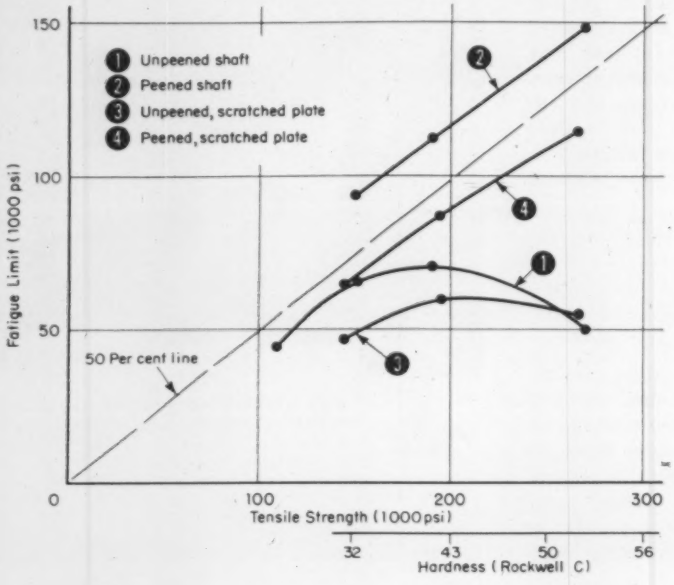


Fig. 5—Fatigue limit as a function of hardness for peened and unpeened specimens

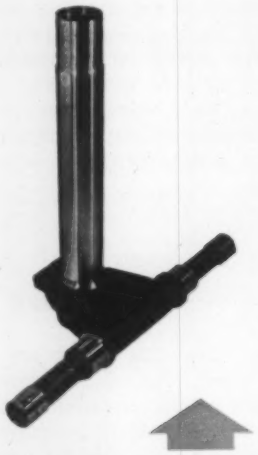


Fig. 6—Aircraft landing-gear part of ultrahigh-strength steel is shot peened to overcome effects of decarburization

Shot peening is used successfully to overcome dangers of surface damage in vital components such as propellers.[7] Steel specimens were shot peened and then hit by glass splinters to produce surface scratches about 0.005-in. deep. Fatigue limits of peened and unpeened parts, plotted over depth of the compressively stressed skin produced by peening, Fig. 8, show that prior peening maintains the fatigue limit of the part (even after surface damage has occurred) above the fatigue limit of the unpeened, undamaged part. Results of tests on specimens heat treated to various hardnesses, Fig. 5, follow the trend previously established, i.e., as steel hardness increases, effect of shot peening on fatigue strength becomes more pronounced. This effect is particularly noticeable with the higher hardness ranges.

Most applications of shot peening in the past were concerned only with increased fatigue durability. Shot peening can be used in a much wider field to obtain higher static strength, as well as better fatigue resistance, by application to steel parts that are so hard they would be brittle without peening. With further development of this technique, great savings of cost, as well as of weight and space, will result. Grossman showed that the brittle-transition temperature was 60 F lower and the permissible strain-rate 20 times higher on shot-peened specimens than on otherwise equal specimens without peening.[10]

Grinding may damage the fatigue life of hard materials. Extent of damage depends on severity of the grinding operation. By shot peening after grinding, the damage can be entirely overcome and beneficial effects of shot peening achieved. Severe grinding with shot peening gives an endurance limit 40 per cent higher than gentle grinding without shot peening, while severe grinding alone lowers the endurance about 30 per cent below that of gentle grinding, Fig. 9.[11]

Plating by itself or plating on ground surfaces, may also produce damage that can be completely overcome by peening before plating, Fig. 10.[12] Landing-gear parts, Fig 5, are chrome plated after shot peening so that cracks which form in the chrome do not propagate into the steel and cannot harm fatigue life of the part.

Effect of Peening

Benefits of shot peening result in part from work-hardening of susceptible material, such as stainless steel, but mainly from presence of residual compressive stresses produced by the treatment. If only one side of a sheet or strip is treated, the effect is readily visible because the compressed side tries to expand and, in doing so, bends the part. This bending induces a small compressive stress on the untreated side so that equilibrium of forces and bending moments in the cross section is established.

Careful removal of layers and observation of changes in curvature permit distribution of re-

sidual stresses to be determined. Distribution of residual stress measured in this manner on shot-peened carburized steel, spring steel, and aluminum is shown in Fig. 11. Difference in intensity corresponds to difference in depth of the compressively stressed skin; peak stress and surface stress depend on the material—not on intensity. Peak stress slightly below the surface is typical of the distribution shown by many similar measurements. In general, on materials that do not strain harden substantially, maximum residual stress is around half the static yield strength of the material. Where strain hardening is a factor, residual stress may be higher and may depend on peening intensity. Residual stress will also be higher when peening is done with the material under strain. Residual stress can then reach the static yield strength of the material.

Relation Between Residual Stress and Fatigue Life: Theoretical explanation of benefits obtained by shot peening and similar treatments depends upon relation between residual stress and fatigue life. Since fatigue failures are cracks and cracks never open unless adjacent particles are pulled apart, it may be assumed that cracks cannot start in a compressed layer, nor propogate into it.

Detailed research shows to what extent this hypothesis is true.[13] Results of fatigue tests, with the permissible-stress range plotted over the mean stress, indicate that the permissible-stress range increases in going from tensile average stress to compressive average stress, Fig. 12. Recent work based on best available test data, indicates fatigue is a function of alternating shear stress and average normal (compressive or tensile) stress, and that permissible range of alternating stress increases as average stress becomes more compressive and decreases as average stress becomes more tensile.[14] This relation for tension and compression is shown in Fig. 13. Increase of permissible alternating stress, when the average stress is compressive, is

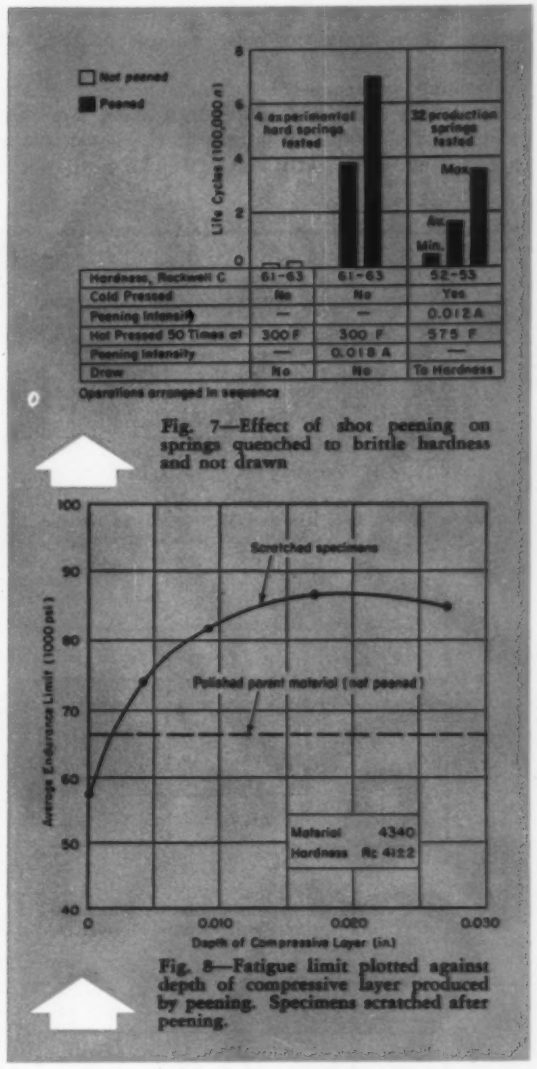
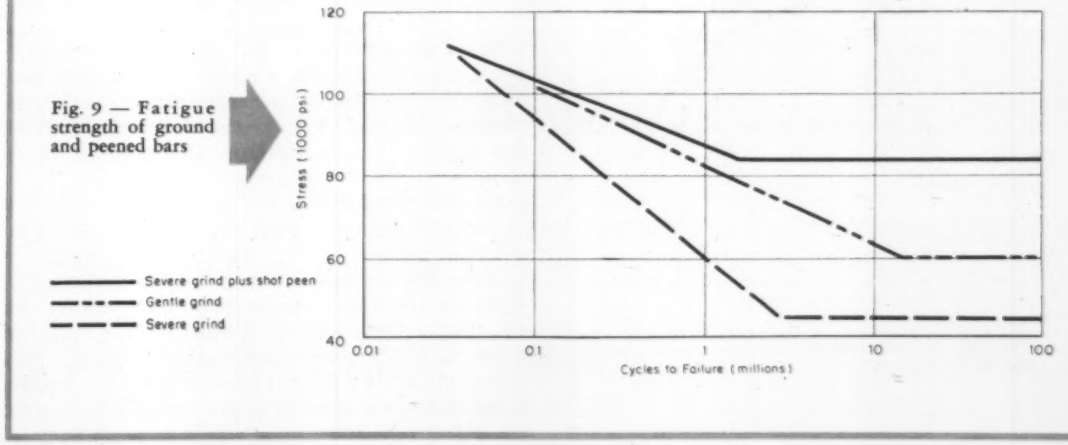


Fig. 7—Effect of shot peening on springs quenched to brittle hardness and not drawn

Fig. 8—Fatigue limit plotted against depth of compressive layer produced by peening. Specimens scratched after peening.

Fig. 9 — Fatigue strength of ground and peened bars



indicated by slope of the cross-hatched area upward on the compressive side and downward on the tensile side. This area encloses large numbers of test points taken from the most reliable of the test results.

Peening overcomes brittleness because plastic deformation necessary to produce small local adjustments can take place only if the shear stress has a value sufficiently high. Cracking will occur when tensile stress reaches a limit value. Treatment must then permit a high shear stress with a low tensile stress—this is done by providing compressive prestress. The same stress acting inside a part is less dangerous than when it acts at the surface, because the surface is subjected to damaging influences from minute imperfections, traces of corrosion, cracks, and lack of cohesion.[15]

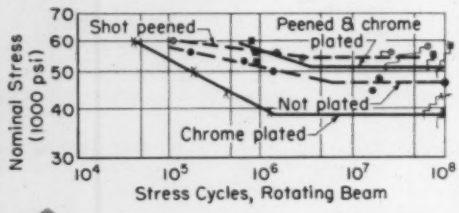


Fig. 10—Fatigue strength of chrome-plated steel, peened and unpeened

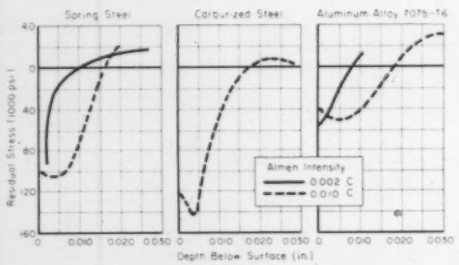


Fig. 11—Distribution of residual stress in spring steel, carburized steel, and aluminum

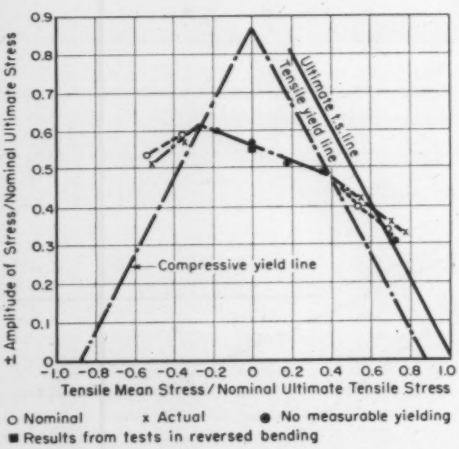

± Amplitude of Stress/Nominal Ultimate Stress
Ultimate t.s. line
Tensile yield line
Compressive yield line
Tensile Mean Stress / Nominal Ultimate Tensile Stress
○ Nominal
× Actual
● No measurable yielding
■ Results from tests in reversed bending

Fig. 12—Effect of mean stress on fatigue

Yield Strength Effects: Residual stresses (like any other stresses) remain as long as total stress (load stress plus residual stress) has not exceeded yield strength. Yield strength for repeated loading is lower than the statically measured yield strength by 25 to 40 per cent, as shown by the well-known settling of springs, Fig. 14, and by published test data.[16,17]

These considerations explain why shot peening and similar treatments based on residual stresses become less effective for higher ranges of alternating stress and must lose their effectiveness when the stress range reaches twice the dynamic yield strength. Under such conditions, residual stress would disappear and only the effect of strain hardening would remain. Testing will, therefore, fail to show benefits from peening if test stresses are appreciably higher than service stresses. Practical solution to such limitations is, of course, found by using material of higher yield strength, such as very hard steels.

Heat may lower yield strength and thus diminish or destroy effect of residual stresses. For spring steel tested at high stress ranges, benefit of shot peening remains fully effective up to 500 F and partially effective up to 800 F.[18] For other materials and other stress ranges, results are different, depending on effect of temperature on dynamic yield strength.

Plastic Deformation from Peening: Residual stresses produced by shot peening result from plastic deformation produced by the shot striking the workpiece. Microphotographs of sections taken below an indentation indicate extent of plastic deformation taking place. Typical indentations of a large ball of soft steel are shown in Fig. 15 and 16.[19] A considerable amount of cold working takes place; depth of cold-worked area is proportional to diameter of impression, regardless of depth or of ratio of depth to diameter. Cold-worked area extends sidewise away from center of indentation over a distance considerably exceeding diameter of indentation. The last two observations are important for specification of effective shot-peening treatment, regardless of material involved.

Surface roughness bears little relation to depth of worked layer—to achieve a certain minimum depth of worked surface layer, it is not necessary to have 100 per cent coverage on the surface, i.e., there may be some distance between one dimple and the next as long as this distance is less than the width to which plastic deformation extends. This fact explains why 100 per cent coverage by dimples is not absolutely necessary, although it is, of course, the safest objective. In a highly stressed surface,

unpeened areas of several dimple diameters will always become the origin of fatigue cracks.

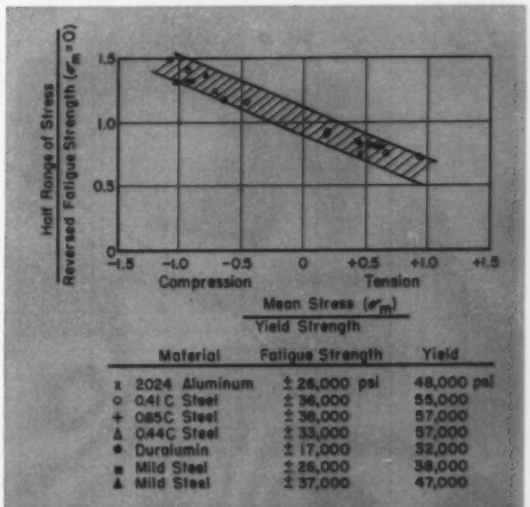
Shot-Peening Specifications

Shot peening intensities can be measured easily and with a high degree of significance. The standard Almen test precedure, combined with applications of shot peening, has resulted in a series of official specifications for the process.[20] Specifications should stipulate intensity of peening for a given section thickness, details and tolerances of shot to be used, inspection procedure, and subsequent or prior treatments.[21]

Choice of Intensity: Peening intensity for steel is given by specifications in Table 1. Generally, minimum required intensity should be chosen, because higher intensities can only be achieved at higher cost. Thin sections can be damaged by excessive peening intensity. For general applications, an intensity of 0.010 to 0.014 A will be satisfactory. To some extent, intensity is also dictated by shape of the part; projecting edges may be damaged by too great an intensity, particularly on very hard or carburized materials.

For steel springs, equal Almen intensities give equal increases in fatigue life, regardless of shot size or material. This is probably also true for other parts made of steel in the hardness range of rockwell C 35 to 55. For much softer materials, this does not hold true. For instance, if the velocities of soft shot and of hard shot are adjusted to have equal effects on Almen strips, on aluminum the soft shot at the higher velocity will produce a deeper layer of compressive stresses.[22] If the velocities of large and of small shot are adjusted to have equal effects on Almen strip, on aluminum the large shot at lower velocity will produce a deeper compressed skin.[23]

To allow for these differences without forcing



	Material	Fatigue Strength	Yield
x	2024 Aluminum	± 26,000 psi	48,000 psi
o	0.41 C Steel	± 36,000	55,000
+	0.65 C Steel	± 38,000	57,000
Δ	0.44 C Steel	± 33,000	57,000
•	Duralumin	± 17,000	32,000
■	Mild Steel	± 26,000	38,000
▲	Mild Steel	± 37,000	47,000

Fig. 13—Effect of normal stress on permissible alternating shear stress (endurance range)

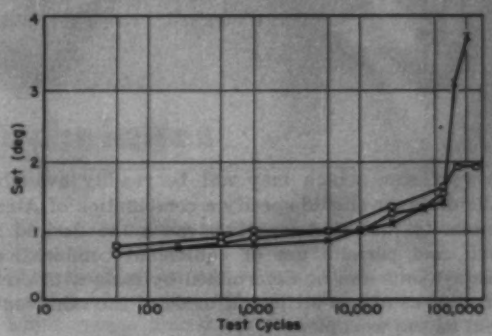


Fig. 14—Settling of coil springs during fatigue testing

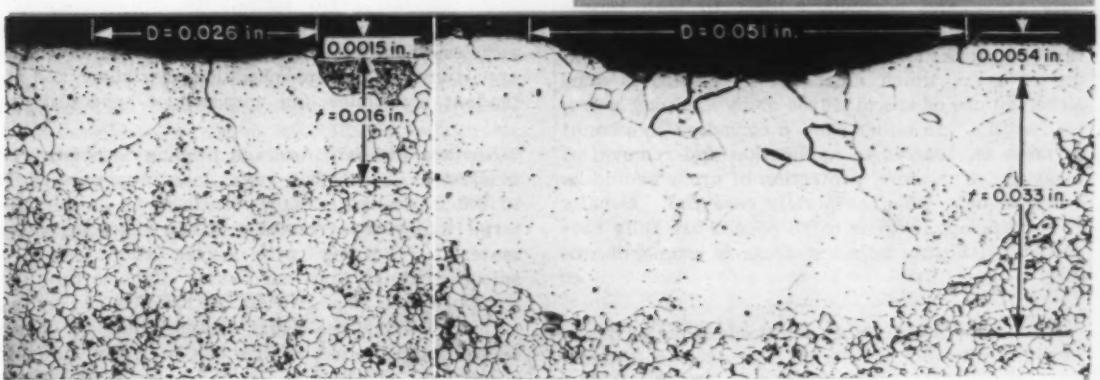


Fig. 15—Microphotograph of grain growth under shallow indentation made by ¼-in. ball

Fig. 16—Microphotograph of grain growth under deep indentation made by ¼-in. ball

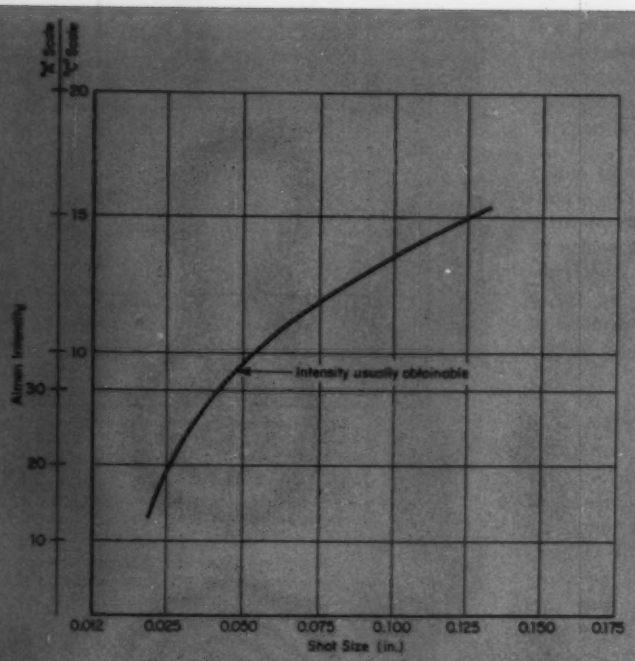


Fig. 17—Relation of shot size to peening intensity

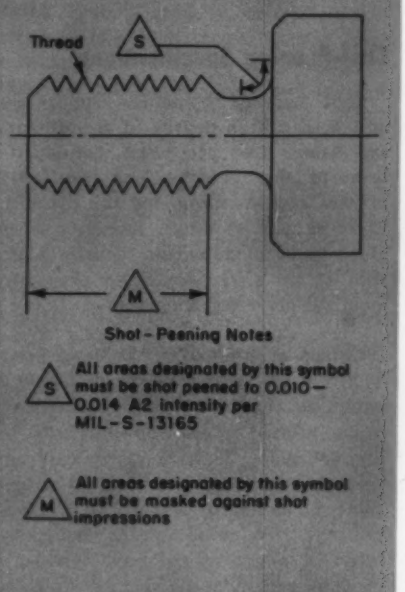

Thread
S
M
Shot-Peening Notes
All areas designated by this symbol must be shot peened to 0.010—0.014 A2 intensity per MIL-S-13165
All areas designated by this symbol must be masked against shot impressions

Fig. 18—Drawing of typical part, with peening notes and specifications

use of shot which may not be readily available, the designer should specify a combination of Almen intensity and shot size that gives the desired result and permits use of equivalent combinations. Equivalents can be determined by tests with strips similar to Almen strips but made of the same material as the workpiece.[23]

Masking: Only in a limited number of cases is peening of the entire part required, coil springs, for instance. In most engineering applications, only areas and portions subject to high tensile stresses need be treated. In other cases, highly finished areas must be protected from shot. Masking of areas which must not be peened is done either by use of special tapes or by applying a protective film. In either case, a considerable amount of labor is involved in application and removal of masking. Therefore, protection of areas should be specified only when absolutely essential. Usually it is sufficient if areas to be peened are fully covered. Shot hitting adjacent areas is usually harmless.

Shot Size: Larger shot can produce higher peening intensities but smaller shot produces full coverage more quickly, Fig 17. High intensities that require large shot (and consequent slow coverage) are more costly but are sometimes worthwhile on the softer materials.

Use of shot sizes larger than required to achieve the desired intensity results in a smoother surface appearance and deeper penetration on aluminum parts. Consequently, it has become customary to prescribe a minimum shot size for aluminum parts where surface appearance is significant.

Need to peen into small-radius fillets may indicate a practical maximum limit on allowable shot size. A generally accepted rule of thumb permits use of a shot size (diameter) no larger than one-half the smallest fillet radius on the surface to be peened. Parts with small radius fillets cannot be peened to high intensities.

Within the given limits, the drawing callout should not stipulate a particular shot size. Any permissible leeway in shot sizes will permit more opportunity for setup, scheduling flexibility, and attendant economies and speeding of schedules.

Surface Finish: Average peening treatment on medium-hard steel will result in a roughness of 65 to 200 mu-in. rms. Same treatment on harder material will give a smoother finish than on softer material. Peening with softer shot leaves a smoother finish than hard shot. Shot softer than the workpiece may give all the benefits of peening without leaving the usual surface dimples. High spots of the peened surface can be lapped down if necessary.

Processing Sequence: Shot peening is a finishing treatment; its value is spoiled by almost any subsequent machining or heat treating processes. Thus, most operations should properly precede peening.

Heating into the stress-relieving range will destroy the residual surface stress—so will any hardening heat treatment. However, parts may be baked at temperatures not exceeding 500 F for steel or 250 F for aluminum alloys. The compressed surface layer is only a few thousandths of an inch thick, so any grinding or machining operations remove most of that layer. A light lapping or honing treatment after peening is permissible and is actually advantageous as far as the fatigue strength is concerned. In some cases, lapping about 0.002 in. from the surface will double the fatigue life. However, greater surface removal may completely spoil the effect of peening. Any cold-forming processes performed after peening may result in a complete reversal of residual stresses and should be avoided.

Peened surfaces present an excellent base for any organic or inorganic coating treatment not requiring heating (apart from a low-temperature bake) such as paint, phosphating, etc. Peened surfaces are highly receptive to oils for rust prevention and lubrication.

Peening Specifications on Drawings: Drawing callouts must include intensity and area to be peened. Reference to shot size and material may be included and, if essential, a note on areas which must be masked. As in all engineering processes, excessively small tolerances in any of these specifications multiply costs and should be avoided. The question is not, "How accurate can the part be" but "How much deviation from the standard will cause damage?" Both speed and size of peening shot are accurate only within commercial tolerances; more stringent demands cost extra money. Intensity tolerances of ± 0.002 A are good commercial practice.

Testing: In addition to the peening specifications, a drawing may also specify test procedures. Here, too, excessive requirements should be avoided, with the additional proviso that overtesting may hide the effects of peening. For instance, a part in service has a maximum deflection of ½ in. Testing that part to a deflection of 1 in. may completely hide shot-peening effects that are very beneficial to the part under service conditions. This hiding happens because overtesting forces the part to yield and thus dissipates beneficial residual stresses.

An example of a peening specification on a drawing is shown in Fig. 18. The threaded portion of the part must obviously not be peened at all, while the turned portion can stand stray shot because such marks are not harmful to fatigue life.

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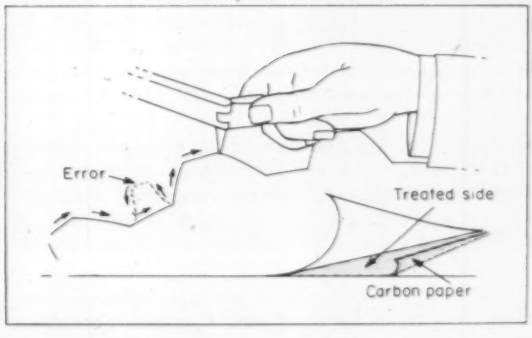
Tips and Techniques

Planimeter Aid

When tracking an odd shape with a planimeter, the stylus often slips off the line. If a sheet of carbon paper is placed coated-side up beneath the

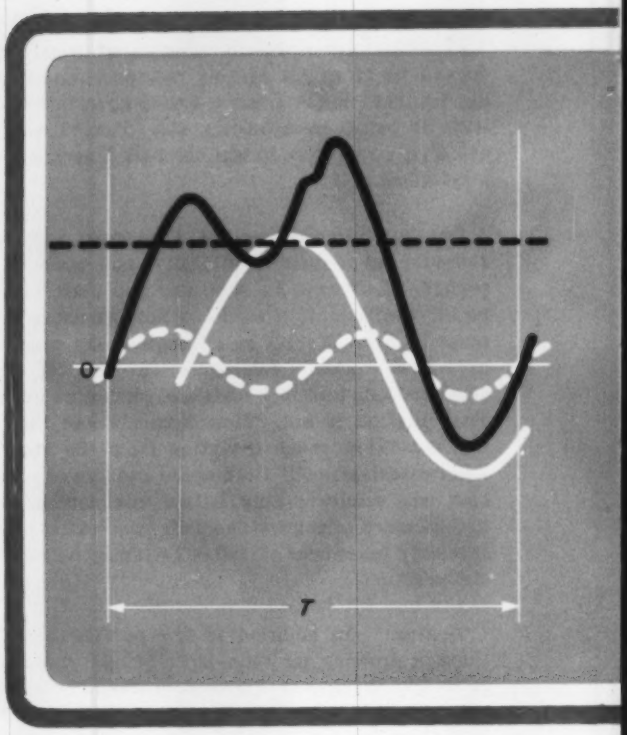


tracing paper, the pressure of the stylus will trace its own path. The area of any error may be subtracted simply by counterclockwise tracking the stylus path of the error as marked by the carbon line.—WILLIAM G. FLANNELLY, *stress engineer, Kaman Aircraft Corp., Bloomfield, Conn.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

By J. M. NIGHTINGALE
Manchester, England

Methods for Transient



USEFULNESS of frequency-response techniques in the design of closed-loop systems has been emphasized by recent articles in this group.[1-16] The main advantage is that the characteristics of the component elements of the loop can be combined by simple arithmetical manipulations of addition and multiplication. Also, since the relationship between open-loop and closed-loop characteristics is clear-cut in the frequency domain, it is possible to use open-loop curves for system design.

Pure sinusoidal input functions are unlikely to be encountered in practice, and the response to more realistic inputs should be considered. In an attempt to represent severe demands on the system a designer usually considers impulse, step, and constant-velocity input functions. Although these are rather idealized inputs it is possible to assess response to them in terms of a few simple criteria.[3]

The task of determining response to these or more general inputs is very difficult for other than simple systems. To attempt to design complex servos in terms of transient response would be tiresome unless special techniques were available. In earlier articles some simple empirical relations between frequency and transient response were given. But these are not rigorous. Hence, even if the frequency response is satisfactory according to gain and phase margins, etc., it is not certain that the transient response will be at all satisfactory. Therefore, as a final check on design values, it is highly desirable to plot the transient response, usually to a step-function input. This may be approached either from knowledge of the harmonic-response function or directly from the transfer function. Of these the latter is perhaps more general, although the former is very convenient.

As a background for the techniques to be outlined, the simple concept of frequency response will be a starting point and from it the idea of Fourier and Laplace transforms will be developed.

Fourier's Theorem: More general types of functions than sinusoids are general periodic functions, Fig. 1. Here the repetition period is T. Fourier's theorem is a mathematical way of saying that the periodic function can be broken down into a constant, or "dc," component, plus a fundamental sine wave of period T, plus second, third and higher harmonic components. Mathematically

$$\theta_i(t) = \sum_{n=-\infty}^{\infty} c_n e^{jn\omega_0 t} \qquad (1)$$

where $\omega_0 = 2\pi/T$ = fundamental frequency.

For convenience, the exponential form has been used for harmonic components. Hence the c_n coefficients, denoting the relative amplitude and phase of each component, are in general complex. They are determined by

$$c_n = \frac{1}{T}\int_{-T/2}^{T/2} \theta_i(t) e^{-jn\omega_0 t}\, dt \qquad (2)$$

An important feature of linear systems is that the response to an input containing several components is the sum of the responses to the separate components. Thus, in this case, the response is the sum of responses to the dc term and fundamental and higher harmonics. Thus if $Y_c(j\omega)$ is

[1]References are tabulated at end of article.

determining

Response of Servo Systems

Part 1—Relation between Frequency Response and Transient Response

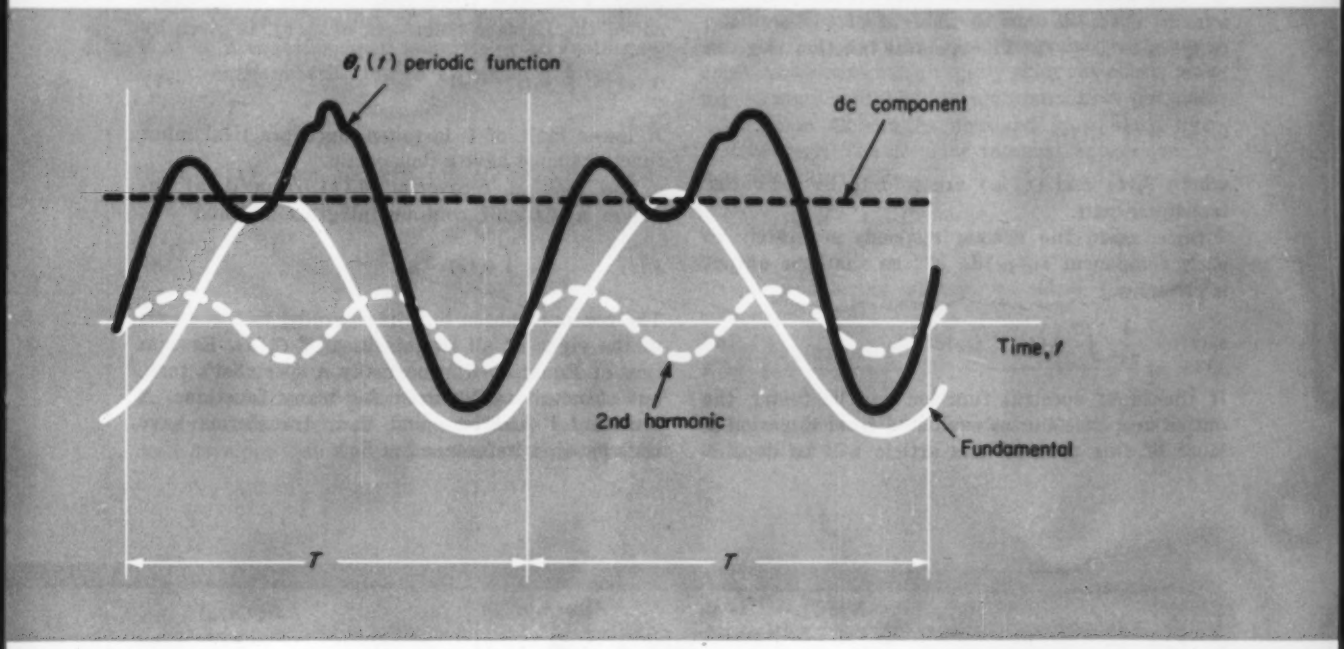


Fig. 1—Periodic input function. By means of Fourier's theorem it is possible to evaluate dc component, and fundamental and higher harmonics.

the overall harmonic-response function for frequency ω, the system output is

$$\theta_o(t) = \sum_{n=-\infty}^{\infty} c_n Y_c(jn\omega_0) e^{jn\omega_0 t} \qquad (3)$$

Thus each component is amplified and phase-shifted according to the value of $Y_c(j\omega)$ at its particular frequency. Diagrammatically this can be illustrated by means of a frequency spectrum for $\theta_i(t)$. This is shown in Fig. 2*a*; Fig. 2*b* shows a typical response function. These may be combined to give the spectrum of the output as shown in Fig. 2*c*.

Although more general than sinusoidal functions, periodic functions are still too restrictive to be classed as general inputs. Therefore, can the

Nomenclature

$A(t)$	= Response to unit-step function
s	= Complex frequency variable
T	= Periodic time
t	= Time variable
$U(\omega), V(\omega)$	= Real and imaginary parts of $Y_c(j\omega)$
$u(t)$	= Unit-step function
$W(t)$	= Weighting function
$Y_c(s)$	= Overall complex frequency-response function
$\delta(t)$	= Unit-impulse function
$\Theta_i(s), \Theta_o(s)$	= Tranformed input and output
$\theta_i(t), \theta_o(t)$	= Input and output
ω	= Frequency variable

spectrum ideas be extended to an aperiodic function, Fig. 3*a*? This can be done by the Fourier integral theorem, which states mathematically

$$\theta_i(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \Theta_i(j\omega)e^{j\omega t}\,d\omega \qquad (4)$$

Equation 4 is developed from Equation 1 by first assuming function $\theta_i(t)$ to be part of a periodic wave of very large period T. Such a periodic wave would have a discrete frequency spectrum of spacing $2\pi/T$. Then if T is considered to become infinite, the segment of the periodic wave becomes the aperiodic function. Also the spectrum closes up and becomes ultimately a continuous curve, Fig. 3*b*. Then instead of definite components at 0, ω_0, $2\omega_0$, . . . , the harmonic components become continuously distributed throughout all frequencies. An amount $\Theta_i(j\omega)d\omega$ can be thought of to lie in the range ω to $\omega + d\omega$. The spectral function is given by

$$\Theta_i(j\omega) = \int_{-\infty}^{\infty} \theta_i(t)e^{-j\omega t}\,dt \qquad (5)$$

where $\theta_i(t)$ and $\Theta_i(j\omega)$ are said to be a Fourier transform pair.

Once again the system responds separately to each component $\Theta_i(j\omega)d\omega\ e^{j\omega t}$ so that the output is given by

$$\theta_o(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \Theta_i(j\omega)Y_c(j\omega)e^{j\omega t}\,d\omega \qquad (6)$$

If the input spectral function can be found, the output response can be evaluated from Equation 6. Most of this part of this article will be devoted to approximate methods of achieving this. These approximations have to be used because it is often impossible to obtain $\Theta_i(j\omega)$ explicitly. The necessary condition for doing so is that

$$\int_{-\infty}^{\infty} |\theta_i(t)|\,dt$$

exists as a finite value. This is not easily satisfied; for example, step-function input violates this condition. For this reason the Laplace transform method is much more powerful.

Laplace Transform Method: Briefly this method splits $\theta_i(t)$ into damped sinusoidal components, e^{st}, where $s = \alpha + j\omega$, each component being $\Theta_i(s)$ $e^{st}ds$. Since s is complex, $\Theta_i(s)$ is a function of a complex variable. Analogous to Equation 5, $\Theta_i(s)$, called the Laplace transform of $\theta_i(t)$, is given by

$$\Theta_i(s) = \int_0^{\infty} \theta_i(t)e^{-st}\,dt \qquad (7)$$

A lower limit of 0 is taken since practical input functions must have a time origin.

The task of recovering $\theta_i(t)$ from $\Theta_i(s)$ involves a difficult contour integration. Thus

$$\theta_i(t) = \frac{1}{2\pi j}\int_C \Theta_i(s)e^{st}\,ds \qquad (8)$$

The contour chosen is a line parallel to the ω axis to the right of all singularities of $\Theta_i(s)$. Evaluation of Equation 8 is normally a specialist's task, but standard tables exist for many functions. A few useful functions and their transforms have been listed in Reference 2.

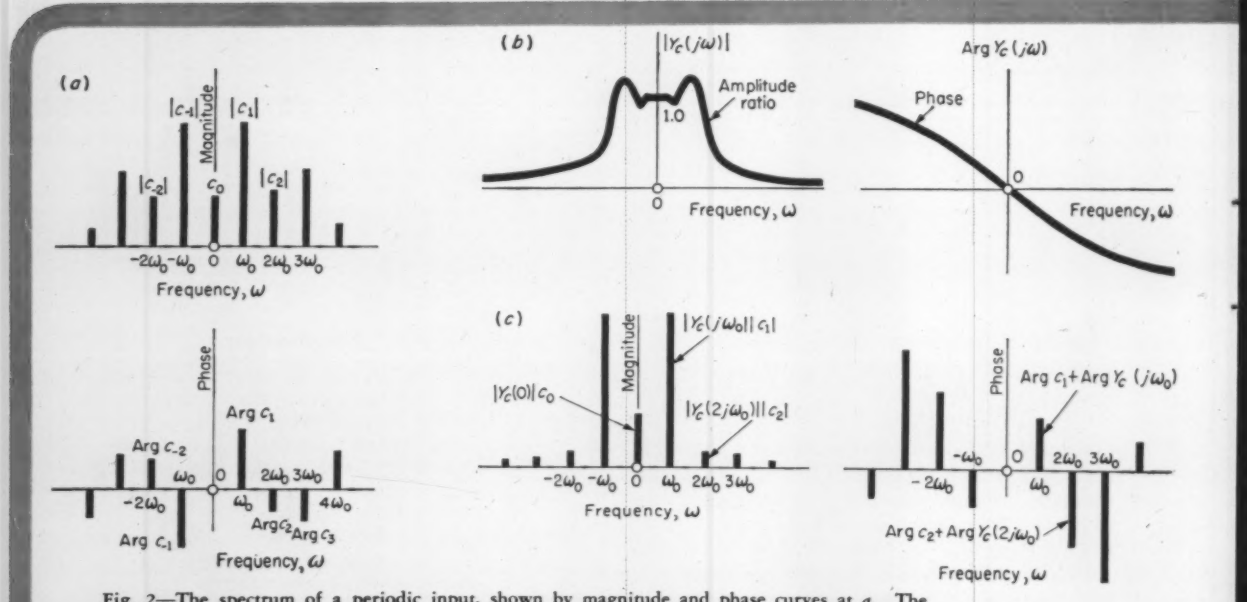


Fig. 2—The spectrum of a periodic input, shown by magnitude and phase curves at *a*. The spectrum occurs at discrete multiples of the fundamental frequency ω_0. The amplitude and phase curves of a typical system are shown at *b*. These act on the input spectrum to produce the discrete output spectrum at *c*.

Again by linear superposition, the output is the sum of the responses to the component damped sinusoids. Thus the output complex frequency spectrum is given by $\Theta_0(s) = Y_c(s)\,\Theta_i(s)$. As a time function,

$$\theta_o(t) = \frac{1}{2\pi j}\int_C Y_c(s)\Theta_i(s)e^{st}\,ds \qquad (9)$$

Methods of overcoming this formidable integral will be discussed in a later part of this article. Here the calculation of output response from Equation 6 is resumed.

Output Response: The response to a δ-type impulse is called the weighting function $W(t)$ of the servo. The response to unit step function is denoted by $A(t)$.

The spectral function of a δ function is unity. That is, it contains equal amounts of all frequency components. Substituting in Equation 6 gives

$$W(t) = \int_{-\infty}^{\infty} Y_c(j\omega)e^{j\omega t}\,d\omega \qquad (10)$$

Since $W(t)$ must be zero for all negative time, this can be simplified to

$$W(t) = \frac{2}{\pi}\int_0^{\infty} U(\omega)\cos\omega t\,d\omega \qquad (11a)$$

or

$$W(t) = \frac{-2}{\pi}\int_0^{\infty} V(\omega)\sin\omega t\,d\omega \qquad (11b)$$

Exact evaluation of these integrals is usually very difficult, but a number of approximate ways have been developed, as well as mechanical computation aids. Better approximations can be found for $A(t)$ rather than for $W(t)$.

Since from Reference 2,

$$A(t) = \int_0^t W(t)\,dt$$

one gets

$$A(t) = U(0) + \frac{2}{\pi}\int_0^{\infty}\frac{V(\omega)}{\omega}\cos\omega t\,d\omega \qquad (12a)$$

or

$$A(t) = \frac{2}{\pi}\int_0^{\infty}\frac{U(\omega)}{\omega}\sin\omega t\,d\omega \qquad (12b)$$

Either Equation 12*a* or Equation 12*b* can be used to find $A(t)$ but one integrand will usually converge to zero more rapidly than the other, making it more suitable for approximation purposes.

Equation 12 can be obtained in a more illustrative way. The Fourier integral expression for unit step function is

$$u(t) = \frac{1}{2} + \frac{1}{\pi}\int_0^{\infty}\frac{\sin\omega t}{\omega}\,d\omega \qquad (13)$$

Then, considering system response to separate components,

$$A(t) = \frac{Y_c(0)}{2} + \frac{1}{\pi}\int_0^{\infty}\frac{M(\omega)\sin(\omega t+\phi)}{\omega}\,d\omega \qquad (14)$$

A little manipulation then leads to the two forms of Equation 12.

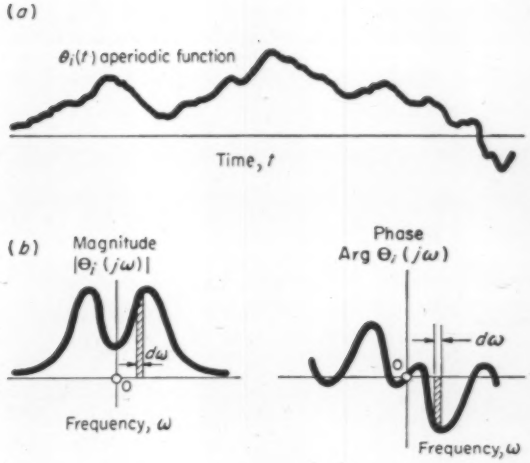


Fig. 3—For a general aperiodic input function frequency, components do not occur at discrete values but are distributed continuously. Fourier integral enables one to obtain for a general function at *a* the continuous spectrum at *b*.

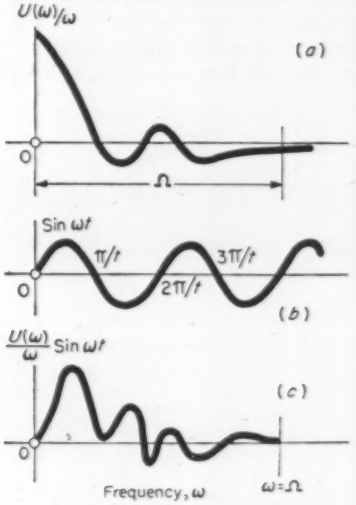


Fig. 4—Typical functions involved in Fourier integral calculation of $A(t)$. $U(\omega)/\omega$ or $V(\omega)/\omega$ is plotted at *a*, while *b* shows sin ωt for a particular time instant t. The product of these functions at *c* is the required integrand.

Approximate Evaluation of Integrals: Fig. 4*a* shows the variation of a typical function $U(\omega)/\omega$ against ω, and in Fig. 4*b* $\sin \omega t$ is plotted against ω. The product of these two functions is the integrand of Equation 12*b*, Fig. 4*c*. For computation the integrand must be finite at $\omega = 0$ and should converge rapidly. If not, the other component must be used or else some other artifice used.[17] Computational integration must stop at a finite frequency Ω. Errors involved will be small if Ω is chosen sufficiently large.

The order of error can be estimated if U/ω or V/ω (whichever is used) is approximated by c/ω^2 for $\omega > \Omega$, where $c = \Omega U(\Omega)$ or $\Omega V(\Omega)$. Then a pessimistic estimate of the error is $2U(\Omega)/\pi$ or $2V(\Omega)/\pi$.

A series of aids for carrying out this computation is based on approximating the form of U/ω or V/ω up to $\omega = \Omega$. One method[18] approximates the curve as the sum of a number of trapezoidal components, chosen by cut-and-try, Fig. 5*a*. Then the response is the sum of the contributions due to the separate trapezoids. One such trapezoid is shown in Fig. 5*b*, suitably labelled. The response component due to this trapezoid is

$$\theta_o(t) = \frac{2A_t}{\pi}\left[\frac{\sin\left(\frac{\omega_b - \omega_a}{2}\right)t}{\left(\frac{\omega_b - \omega_a}{2}\right)t} \times \frac{\sin\left(\frac{\omega_a + \omega_b}{2}\right)t}{\left(\frac{\omega_b + \omega_a}{2}\right)t}\right] \qquad (15)$$

where A_t is the area of the trapezoid. All such components must be added. Both terms in square brackets in Equation 15 are of the form $(\sin x)/x$ and this function has been extensively tabulated in Reference 18. By the use of these tables the computation becomes extremely simple.

In another method for performing the integration, U/ω or V/ω is approximated by straight-line segments, Fig. 6. Once again components of response due to the separate segments must be added. The component due to the segment in the interval ω_a to ω_b, if Equation 12*b* is used, is

$$\theta_o(t) = \frac{2}{\pi}\left[\frac{\cos \omega_a t}{t}(a - b) - \frac{\cos \omega_b t}{t}(a + b) + \frac{2b}{(\omega_b - \omega_a)t^2}(\sin \omega_b t - \sin \omega_a t)\right] \qquad (16)$$

If Equation 12*a* is chosen, a slightly different equation[17] must be used instead of Equation 16.

A third method involves the expression of U/ω (or V/ω) as a series of frequency impulses. The curve is divided into strips of width $\Delta\omega$, Fig. 7, and height a_1, a_2, a_3, ... Then each impulse is taken at the center of a strip with weight equal to the area of the particular strip. Thus,

$$\frac{U(\omega)}{\omega} = \Delta\omega \sum_n a_n \, \delta(\omega - \omega_n) \qquad (17)$$

where $a_n = U(\omega_n)/\omega_n$.

Note, a δ function of frequency is defined exactly as a δ function of time[2], except that ω is now the variable.

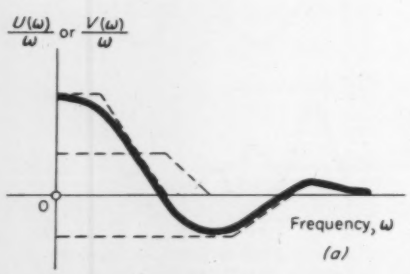
Substituting in Equation 12*b* gives

$$A(t) = \frac{2\Delta\omega}{\pi} \sum_n a_n \sin \omega_n t \qquad (18)$$

Summation should stop at $\omega = \Omega$ as before. A similar method can easily be applied to Equation 12*a*.

Guillemin[19] has developed a method combining straight-line and impulse approximations. Briefly, the first or a higher derivative of U/ω is approximated by straight-line segments. This approximation is then differentiated twice to give a series of impulses as before.

Yet another method is to expand U/ω as a Fourier series[20] with 2Ω as the repetition interval.



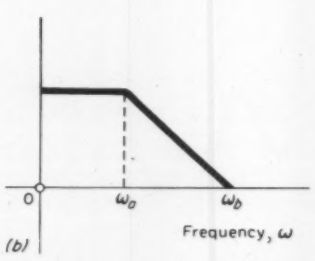


Fig. 5—Approximation to $U(\omega)/\omega$ or $V(\omega)/\omega$ by trapezoidal segments is shown at *a*. A particular trapezoid is shown at *b*.

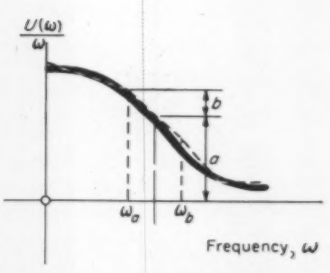


Fig. 6 — Approximation by straight-line segments.

For example,

$$\frac{U(\omega)}{\omega} = \sum_{n=1}^{\infty} a_n \sin\left(\frac{n\pi\omega}{\Omega}\right) \qquad (19)$$

for $-\Omega < \omega < \Omega$. The coefficients can be calculated from

$$a_n = \frac{2}{\Omega}\int_0^{\Omega} \frac{U(\omega)}{\omega} \sin\left(\frac{n\pi\omega}{\Omega}\right) d\omega \qquad (20)$$

Substitution from Equation 19 in Equation 12*b* leads to

$$A(t) = 2\Omega \sin \Omega t \sum_{n=1}^{\infty} \frac{(-1)^{n+1} n a_n}{(n^2\pi^2 - \Omega^2 t^2)} \qquad (21)$$

Usually this expression converges rapidly so that only the first few terms of the series need be evaluated.

Instead of approximating the characteristic of the system it is alternatively possible to approximate the input function. For example, if unit step function input $u(t)$ is replaced by a square wave of duration T, Fig. 8, then the response to the front step of the square will differ little from $A(t)$, provided T is much greater than the settling time of the servo. To tie in with system approximation accuracy, T should be numerically comparable with π/Ω. The simplification to calculation occurs if the square pulse is considered to be part of a repetitive train of period $2T$ (dotted curve, Fig. 8). It is then possible, by Fourier series, to approximate the input by

$$\theta_i(t) = \frac{1}{2} + \frac{2}{\pi}\left(\sin \omega_0 t + \frac{1}{3}\sin 3\omega_0 t + \ldots\right) \qquad (22)$$

where $\omega_0 = \pi/T$. Considering the response to each component leads to

$$A(t) \approx \frac{4}{\pi}\left[U(\omega_0)\sin\omega_0 t + \frac{U(3\omega_0)}{3}\sin 3\omega_0 t + \frac{U(5\omega_0)}{5}\sin 5\omega_0 t\right] \qquad (23)$$

Similar results can be achieved by other approximations to a step function which have finite duration.

Part 2 of this series will deal with the determination of transient response from transfer functions.

References

This article is the seventeenth in a co-ordinated group by J. M. Nightingale on servo systems. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

1. "Automatic Control Systems" ..... May 17, 1956
2. "Servo Mathematics" ..... June 28, 1956
3. "Evaluating Servo System Performance—Part 1" .. July 26, 1956
4. "Evaluating Servo System Performance—Part 2" .. Aug. 9, 1956
5. "Analyzing Servo Systems" ..... Nov. 1, 1956
6. "Hydraulic Servo Components—Part 1" ..... Nov. 29, 1956
7. "Hydraulic Servo Components—Part 2" ..... Dec. 13, 1956
8. "Hydraulic Servo Components—Part 3" ..... Dec. 27, 1956
9. "Hydraulic Servos—Part 1" ..... Feb. 21, 1957
10. "Hydraulic Servos—Part 2" ..... Mar. 7, 1957
11. "Hydraulic Servos—Part 3" ..... Mar. 21, 1957
12. "Improving Servo System Performance—Part 1" ... May 30, 1957
13. "Improving Servo System Performance—Part 2" ... June 13, 1957
14. "Quantitative Design of Servo Systems—Part 1" ... July 11, 1957
15. "Quantitative Design of Servo Systems—Part 2" ... July 25, 1957
16. "Quantitative Design of Servo Systems—Part 3" .. Aug. 8, 1957

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Reprints

Articles listed above by J. M. Nightingale are now available in reprint form. Articles 1 to 5 are contained in Volume 1 (32 pages) and articles 6 to 11 in Volume 2 (32 pages) of "Hydraulic Servo Fundamentals." The volumes are available at $1.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

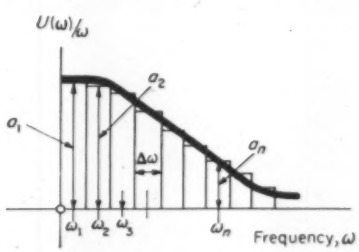


Fig. 7 — Approximation by a series of weighted impulses.

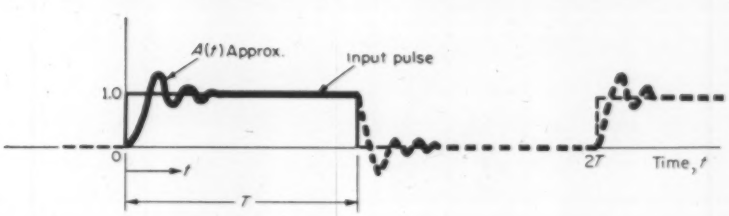


Fig. 8—An approximate expression for transient response can be obtained if input is a repetitive square wave. Response differs little from step-function response if T is much longer than any time constant associated with the system.

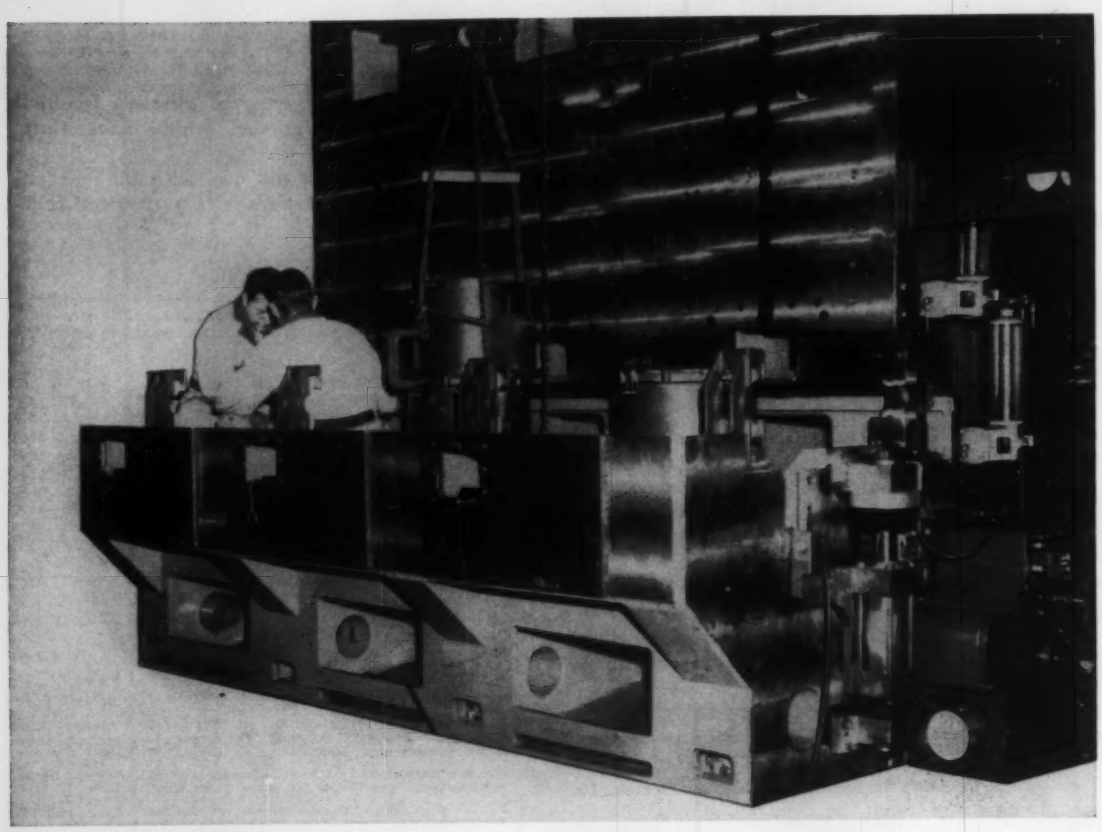


Fig. 1—Above—Machine frame structures vary with application. Economy and short delivery schedules preclude extensive stress and deflection calculations or detailed production methods analyses.

Fig. 2 — Left — Scale models help to visualize design features. When stressed, models deflect in exactly the same manner as their counterpart weldments. Structural members can be added, subtracted or changed and results seen immediately.

Paperboard Models Aid Weldment Design

How weldment deflections in complex modes of loading can be predicted by applying a modulus based on the deflection of a paperboard model under scale load.

BY JACK C. HORTH
Chief Engineer
Machine Tool Div.
Mercury Engineering Co.
Milwaukee, Wis.

SCALE models have come into fairly general use for three-dimensional visualization. They facilitate both qualitative and quantitative evaluation of structures and components, with considerably more flexibility and utility than either blueprints or perspective drawings.

Often, in application-engineered machinery, the same standardized work units are adapted to each assembly. But machine frame structures, Fig. 1, are always different and frequently quite complex.

Amount of time and money that can be spent on stress analysis and deflection calculations is usually restricted on these custom-tailored units. At the same time, they must embody the same properties of rigidity, good appearance and economy of manufacture as do highly engineered units.

Steel plate weldments have been widely accepted as a construction method for special machinery frames. In their design are six basic goals which the engineer must approach:

1. Rigidity
2. Strength
3. Minimum weight
4. Fabricating economy
5. Ease of machining
6. Optimum appearance

Beyond these are factors such as effective arrangement of components, accessibility and maintenance, ventilation, and even problems associated with handling, shipment and installation.

Quarter-scale models of corrugated paperboard, Fig. 2, have proved of invaluable assistance. Problems of stress and deflection can be readily simulated in the model and extrapolated to the full size machine structure. The models, when stressed, will deflect in exactly the same manner, although much magnified, as their counterpart weldments.

The beauty of these sample tests is that a model's behavior can be studied in a great variety of modes, or types of loading. Where relative rigidity is determined only by calculation, the average designer is content to figure simple deflection under a few types of functional load. Indeed, frame design calculations associated with even the most carefully engineered machinery present a faint and incomplete picture of what actually occurs in the service life of the average machine.

A realistic disclosure of reactions to a wide variety of stressing can be obtained in a matter of minutes with paperboard models. Even quantitative measurements can be made. By comparing measured deflection of the model under scale load with calculated deflection of the counterpart weldment under analogous conditions, Fig. 3, a modulus or multiplier factor can be determined for application to deflections measured on the model under different types of loading, Fig. 4, thus giving at least a close approximation of what can be expected from the weldment.

Slight differences in plate thickness generally can be disregarded in the scale model, since the depth of properly designed ribs, rather than their thickness, contributes the major share of stiffness. If the plate thickness does appear to be a significant factor, the corrugated paperboard can be doubled or tripled in thickness by gluing sheets face to face.

Care must be taken to keep test loads below the point where the board buckles, which is equivalent to staying under the yield point in a steel structure. Short of this buckling point, the lay of the paperboard corrugations (or grain direction) seems to have little bearing on deflection. The material bends along or across the grain with almost equal facility.

Another advantage of scale models as aids to designers is that structural members can be added, eliminated or altered easily and the results quickly observed. Ideas that might have been otherwise overlooked can be incorporated as parts of the initial design detail.

Use of the model to arrive at the best arrange-

ment of machine components is particularly helpful. It is especially effective in dealing with outside suppliers who find that the see and feel of what they are to furnish makes their job easier and quicker. And outside vendors are less prone to add on amounts for contingencies.

Similar advantages apply in solving fabrication and machining problems. Designers are better able to figure out methods to minimize costly machining or difficult set-ups. They find it easier to get advice from shop foremen and production personnel when they can substitute a model for a ream of blueprints.

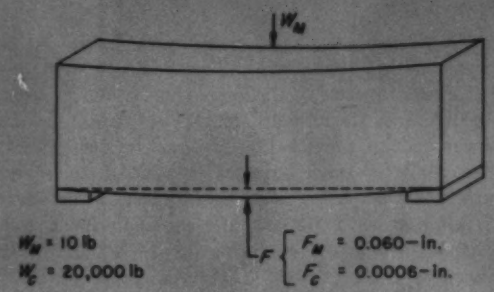
Model materials are sheets of corrugated paperboard, cellulose cement, common pins and masking tape. Pins and tape "tack weld" the model temporarily while cement is laid in fillets and scarf joints, and over butt joints, like an arc weld bead. Model structures take on surprising strength and stiffness as construction progresses and can be handled with little danger of damage. By using blueprints of bulkheads and ribs as templates and tracing them off on the boxboard with carbon paper, or taping them to the board and then slicing through both with a razor blade cutter, much layout time can be conserved.

Nomenclature

E = Ratio of weldment deflection to model deflection, in. per in.
F_C = Deflection of weldment, in.
F_M = Deflection of model, in.
W_C = Assumed equivalent load on weldment, lb
W_M = Actual scale load, lb

Based on an award-winning paper submitted in a recent welding design competition sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, O.

Fig. 3—Determining modulus E for simple mode of loading of weldment model.



Step1: Load the model in a simple mode and measure deflection F_M

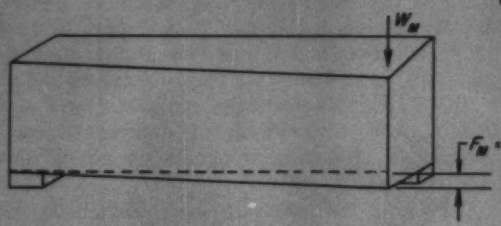
Step2: Calculate equivalent deflection, F_C of weldment, under assumed load W_C

Step3: Calculate modulus E from: $E = F_C / F_M$ For above, $E = \frac{0.0006}{0.06} = 0.01$.

Fig. 4—Modulus E applied to more complex modes of loading to find weldment deflection.

To find weldment deflection, F_C, in any other mode of loading:

Example: To find estimated torsional deflection, F_C, of a weldment with three corners supported and load W_C acting on one corner:

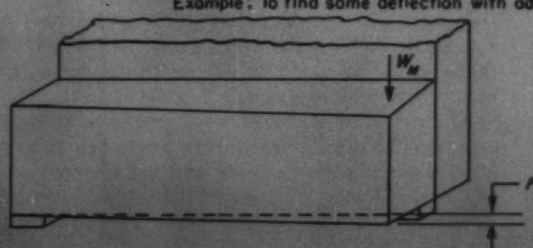


W_M = 10 lb

W_C = 20,000 lb

$F_C = F_M \times E = 0.280 \times 0.01 = 0.0028$ – in.

Example: To find some deflection with added stiffness of bolted-on column frame:



$F_C = F_M \times E = 0.090 \times 0.01 = 0.0009$ – in.

The Personal Side of Engineering

By **EDWIN C. NEVIS**
Personnel Research and Development Corp., Cleveland, Ohio

Your Dependent Boss

THE most important personal relationship on a job is between an individual and his superior. When this relationship is pleasant and mature, based on mutual respect, it can be a source of great satisfaction. But breakdowns in the relationship are the cause of much stress and dissatisfaction.

Why are the superior and subordinate so important to each other? A superior is responsible for more work than one man can do. So he is given subordinates to help him carry out his assigned tasks and objectives. This, of course, is basically the organizational principle of accountability, in which each man is delegated responsibility and authority from his superior and, in turn, is held accountable for the end results of his efforts.

If each person in the chain of command carries out his assigned tasks and holds up his share of the responsibility, the end result is an efficient organization. In other words, if subordinates understand that they are there to help their superior and, on the other hand, superiors can inspire their subordinates to perform as desired without any problems being created in the process, organizational goals would be met.

From a psychological viewpoint, however, the perception of each other's role is different from this straightforward organization theory. As seen by a subordinate, a superior is viewed, not as a man responsible for more work than one man can do, but rather as a person of greater status and authority with more extensive privileges and rewards. Superiors are seen as being more company-oriented, willing to put in longer hours, put up with greater frustrations, and make more sacrifices to achieve company goals. Superiors are also seen as powerful individuals who control recognition, pay and advancement and, hence, as the persons subordinates must satisfy in their work. The relationship from the subordinate's viewpoint is not a simple, logical one, but is burdened with emotional undertones.

Subordinates, as seen by their superior, tend to have less interest in results, partly because they have less privilege, status and reward, but also because superiors frequently fail to recognize that accountability should filter through to subordinates. Superiors may see their subordinates simply and logically as persons who are to get the work done without creating problems or delays. Moreover, superiors can frequently be annoyed at their subordinates, particularly when they are not performing up to par—feeling that the subordinates are not aware of pressures the superior is subjected to.

Thus, psychologically speaking, the picture is not as simple as it first sounds. However, there is one underlying, clear-cut implication. The essential element of the relationship is mutual interdependency. In his own way, each depends on the other for attainment of results and personal satisfaction.

The subordinate depends on his superior for personal recognition, advancement, pay, working conditions, and the like. The superior, on the other hand, depends highly upon the subordinate to achieve the objectives delegated to him. Since the superior is responsible for more work than he can do alone, he must have the help of his subordinates to carry out his assignments.

While this analysis may sound quite obvious, countless studies and daily experiences in industry indicate frequent breakdowns in this important relationship, with a failure to understand each other's role. Superiors, as they hurry after production goals, tend to overlook the needs and wants of their subordinates and the fact that they control the gratification of so many of these desires. Subordinates, in return, are not fully aware of how much their boss depends upon them.

Good supervision could be described as the establishment of an environment where subordinates consider it a privilege and a source of satisfaction to help their superior and to share in his accountability. The first step is to recognize the

dependency each has upon the other and the fact that, whether they consider it desirable or not, each is intimately bound to the other.

To bring about better relations, superiors must be willing to admit by actions and philosophy that they rely on subordinates. This is not a question of competence, where the superior must feel continually on guard lest subordinates think he is not able to do the job. Rather, it is a simple manifestation of the fact that more than one person must work to achieve the group result, and so the superior is essentially helpless without cooperation.

Superiors can help create a willingness to accept and carry out this principle if they show an awareness and appreciation of the needs and wants of their subordinates. If superiors can help the subordinate know where he stands, can involve him in the job situation so he feels like an active, important member of the group, can show approval, and provide opportunities for advancement and personal development, it will be much easier for the subordinate to accept and respond to the superior's dependency upon him.

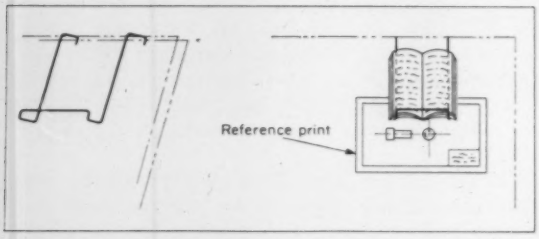
Subordinates, on the other hand, need to recognize their burden of responsibility in this "mutual assistance pact." This requires an acceptance of the fact that their own best interests are interwoven with the objectives and goals of their superior, as these are delegated to him by his superior.

Acceptance of this dependency does not imply that subordinates cannot act independently nor be given assignments to be carried out on their own. Rather, it implies a willingness to co-operate. This may be particularly difficult for such independent-minded persons as engineers and other professionals. But it is an essential fact of modern-day industrial organization which must be dealt with for maximum job satisfaction.

Tips and Techniques

Catalog Holder

Wire can be bent to form a catalog holder for vertical drafting boards and for those which are inclined so that catalogs and reference prints will



not stay on. Formed of wire (such as an old clothes hanger), the unit will hold catalogs, charts, brush or scale. Reference prints may be tucked underneath for convenience.—FRANK ALBERT, JR., *tool designer, Accurate Design Service, Cleveland, Ohio*

Finding Factors

The least common denominator of several fractions is the least common multiple of their denominators, i.e., the number which may be divided by each without leaving any remainder. To find the least common multiple of several numbers, such as 3, 4, 9, 12, 16, is a simple matter of trial and division.

Write the numbers in a row, separating them by commas: 3, 4, 9, 12, 16. The least number to contain 3, 4, 9, 12, and 16 must be the smallest number that will contain the factors of each of them, but no other factors. Therefore, all the prime factors that the multiple contains must be found. Two is a prime factor of 4, 12, and 16. Therefore it must be a factor of any number which contains them without a remainder. Dividing by 2 and writing the quotient below (wherever 2 is a factor)

$$
\begin{array}{r|lllll}
2 & 3, & 4, & 9, & 12, & 16 \\
\hline
2 & 3, & 2, & 9, & 6, & 8 \\
\hline
3 & 3, & 1, & 9, & 3, & 4 \\
\hline
 & 1, & 1, & 3, & 1, & 4
\end{array}
$$

$$2 \times 2 \times 3 \times 3 \times 4 = 144 \quad \text{Ans.}$$

gives 3, 2, 9, 6, 8 (the numbers are written as they stand when 2 is not a factor). Since 2 is also a factor of 2, 6, and 8, divide by it again, in the same manner, to obtain 3, 1, 9, 3, 4. Next, divide by 3. The result is 1, 1, 3, 1, 4. These have no common factor and must be factors of the least common multiple as 2, 2 and 3 are. Disregarding 1's, the factors are $2 \times 2 \times 3 \times 3 \times 4 = 144$, the least common multiple. Note: Disregard a 1 as soon as it appears in a row, since multiplying by it produces no change.—RAWL GERROW, *product designer, Milwaukee, Wis.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Design characteristics of

TITANIUM

By LELAND W. LONG
Mallory-Sharon Titanium Corp.
Niles, Ohio

TITANIUM is available in all standard wrought metal forms. It can be rolled, hammered, pressed or extruded from ingots into blooms, billets, or slabs, and then worked into plate, sheet, strip, bars, rods, and forging billets.

Typical Mechanical Properties of Commercially Pure Titanium

Property	MST-70* Bar	MST-70* Sheet	MST-55† Bar	MST-55† Sheet	MST-40‡ Bar	MST-40‡ Sheet
Ultimate tensile strength (1000 psi)	90	95	80	85	65	70
Yield strength (1000 psi)	80	80	65	70	55	60
Elongation (per cent in 2 in. for sheet, 1 in. for bar)	20	21	21	22	23	25
Reduction of area (per cent)	37	..	45	..	50	..

*MST-70: 0.05 C, 0.03 N, 0.35 Fe, 0.8 other, bal Ti. †MST-55: 0.04 C, 0.025 N, 0.3 Fe, 0.7 other, bal Ti. ‡MST-40: 0.03 C, 0.02 N, 0.25 Fe, 0.6 other, bal Ti.

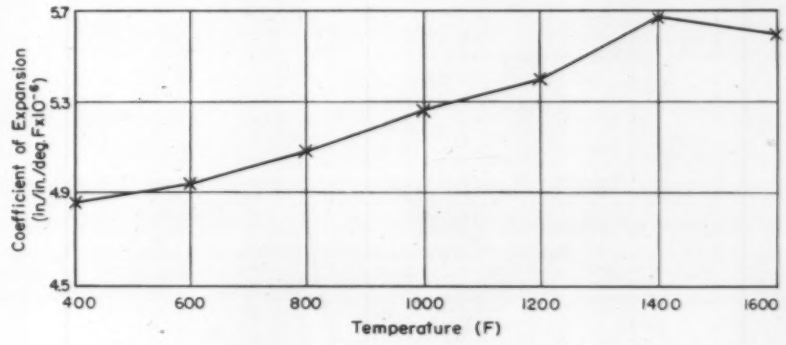
Commercially pure titanium, which is easier to form and machine than the alloys, is usually selected for industrial applications. Where very high strengths are required, titanium alloys are specified. Commercially pure titanium is also used in many airframe applications, primarily for nonstructural parts—in shrouds, fire seals, ammunition, boxes, cowlings, etc.

Commercially pure titanium as produced by Mallory-Sharon is available in three strength ranges:

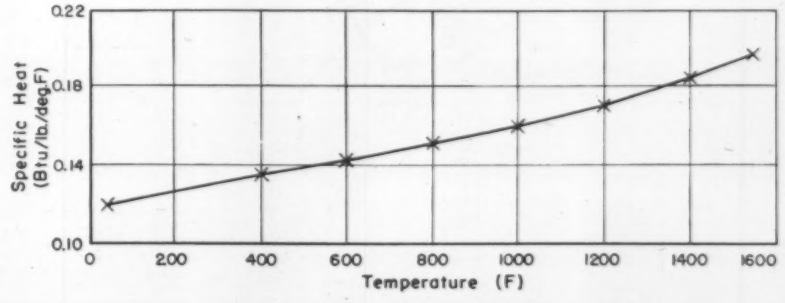
MST-40: 40,000 to 60,000 psi yield strength
MST-55: 55,000 to 80,000 psi yield strength
MST-70: 70,000 to 95,000 psi yield strength

Pertinent mechanical, physical, and corrosion

Effect of temperature on mean linear thermal coefficient of expansion for MST-55 titanium between 68 F and indicated temperature



Effect of temperature on specific heat of MST-55 titanium



properties of these three grades of commercially pure titanium are presented here.

Mechanical and Physical Properties: Melting point of titanium, 3034 F, is higher than that of any metal currently being used as a structural material. The interstitial elements (oxygen, nitrogen, and carbon) and some high-melting-point materials (tungsten, tantalum, columbium, etc.) raise the melting point of titanium. Most other metallic impurities lower the melting point.

Mean Young's modulus for titanium is about half that for iron-base materials. On the other hand, the elastic strength of titanium is not abnormally low compared with metals other than iron, since aluminum, copper, and magnesium have lower values.

Electrical resistivity of titanium at room temperature is remarkably high for a pure metal. Copper, silver, aluminum, and iron are all appreciably better conductors than titanium. In fact, among elements which conduct electricity, only semimetals such as antimony and bismuth have resistivities comparable with that of commercially pure titanium. Austenitic stainless steels, however, have equally low conductivity.

Thermal conductivity and electrical conductivity are closely related since thermal energy is distributed in a metal largely by means of free electrons. Thus, titanium, having low electrical conductivity, also has low thermal conductivity.

Titanium's low specific heat, 0.126 Btu/lb/deg F at room temperature, can be important in cases where rate of heat transfer required to change temperature is critical.

Endurance limit is generally 50 to 55 per cent of tensile strength.

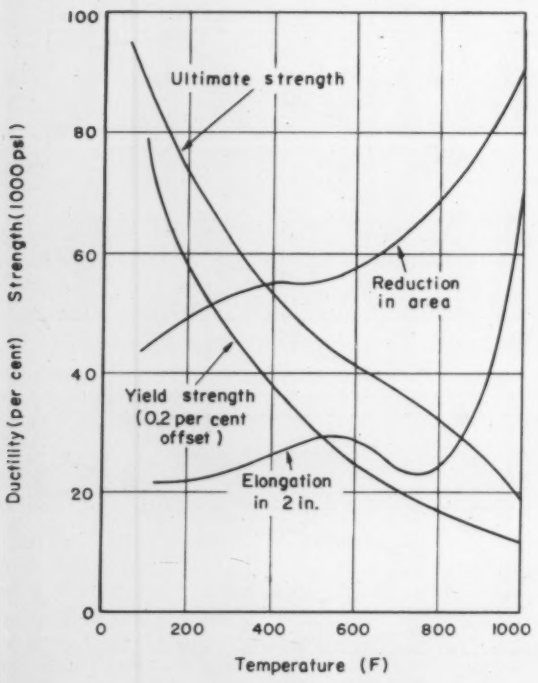
Static coefficient of friction of titanium in contact with itself is 0.49. While titanium has a strong tendency to seize and gall, recent development of various surface coatings has helped to alleviate this problem.

These and other important properties of commercially pure titanium are listed and illustrated in accompanying tables and graphs.

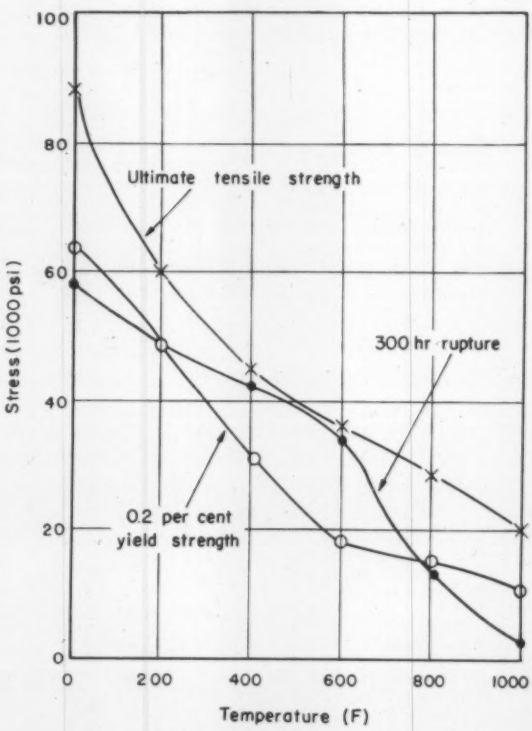
Corrosion Resistance: Another table shows titanium's outstanding resistance to many types of corrosive media, including some of the most troublesome industrial chemicals. It is uniquely superior in resisting corrosion by nitric acid, wet chlorine gas, solutions of chlorine, chlorinated organic compounds, and inorganic chloride solutions. It has

Physical Properties of Commercially Pure Titanium

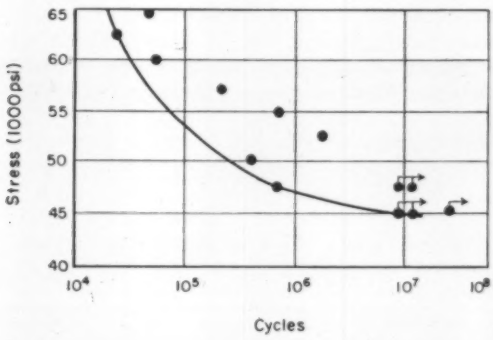
Density	0.164 lb/cu in.
Melting point	3034 F
Modulus of shear	6.5×10^6 psi
Coefficient of expansion	5×10^{-6} in./in./deg F
Specific heat	0.126 Btu/lb/deg F
Magnetic permeability	1.0001
Magnetic susceptibility	3.31×10^{-6} emu
Coefficient of friction	0.49
Poisson's ratio	0.34



Effect of temperature on tensile properties of MST-70 titanium



Tensile and rupture properties of MST-55 titanium



Unnotched fatigue strength of annealed MST-70 titanium sheet whose ultimate tensile strength is 86,000 psi, 0.2 per cent offset yield strength is 72,000 psi, elongation is 23 per cent, and reduction of area is 43 per cent

Young's Modulus of MST-70 Titanium

Temperature (F)	Modulus (million psi)
75	15.5
200	14.5
400	13.5
600	12.5
700	11.8
800	11.2
900	10.6
1000	10.0

Electrical Resistivity of Titanium

Temperature (F)	Electrical Resistivity MST-55 (ohm-cm)	MST-70 (ohm-cm)
68	48.6×10^{-6}	55.5×10^{-6}
200	62.6×10^{-6}	67.7×10^{-6}
400	82.5×10^{-6}	87.6×10^{-6}
600	101.0×10^{-6}	106.8×10^{-6}
800	117.7×10^{-6}	123.8×10^{-6}
1000	132.6×10^{-6}	138.2×10^{-6}
1200	145.3×10^{-6}	150.4×10^{-6}
1400	.....	159.2×10^{-6}
1600	.....	159.2×10^{-6}
1800	.....	150.0×10^{-6}
2000	.....	151.1×10^{-6}

Thermal Conductivity of Titanium

Temperature (F)	Thermal Conductivity (Btu/hr/sq ft/deg F/ft) MST-55	MST-70
−100	11.8	10.3
68	11.5	9.9
200	10.9	9.8
400	10.4	9.7
600	10.5	9.8
800	10.5	10.0
1000	10.7	10.5
1200	11.3	11.2
1400	12.1	11.9
1500	12.5	12.4

Comparison of Corrosion Properties of Titanium, Tantalum, and Type 316 Stainless Steel*

Corrosive Medium	Titanium	Tantalum	Stainless Steel Type 316
Acetic acid	5, 10 per cent 68 F Excellent	All concentrations 68 to 73 F Excellent	5 per cent to glacial 95 to 390 F Good
Aluminum chloride	10 per cent 95, 212 F Excellent	....	....
Ammonium hydroxide	28 per cent Room temperature Excellent	....	All concentrations ..... Good
Aqua regia	65 to 140 F Excellent	65 to 140 F Excellent	....
Calcium chloride	10, 25 per cent 95 to 121 F Excellent	....	5 per cent to saturated 95 to 212 F Poor
Carbon tetrachloride	1 to 99 per cent Boiling Excellent	....	Room temperature ..... Good
Chlorine gas, saturated	Room temperature Excellent	....	....
Chlorine-saturated water	Room temperature Excellent	....	95 to 212 F Poor
Chromic acid	10 per cent Boiling Good	....	10 to 50 per cent 95, 212 F Fair to poor
Cupric chloride	1 to 15 per cent 95 F Excellent	....	1 to 5 per cent 70 F to boiling Poor
Ethyl alcohol	95 per cent Boiling Excellent	....	....
Ferric chloride	1 to 20 per cent 65 to 212 F Excellent	5 to 30 per cent 65 F to boiling Excellent	1 to 5 per cent 70 F to boiling Poor
Formic acid	25 to 90 per cent 95 F to boiling Good to poor	90 per cent 212 F Excellent	5 per cent 160 F Fair to poor
Hydrochloric acid	5 per cent to concentrated 95 to 212 F Poor	19 per cent to concentrated 65 to 212 F Excellent	Dry, moist 68 F Poor
Hydrogen peroxide	30 per cent Room temperature CP—poor ACS—excellent	....	....
Lactic acid	85 per cent 95 F to boiling Excellent	....	5, 10 per cent 95 F to boiling Poor
Mercuric chloride	1 per cent to saturated 95 to 212 F Excellent	Saturated 212 F Excellent	0.5 to 2 per cent 70 F to boiling Poor
Monochloro acetic acid	100 per cent Boiling Excellent	....	....
Nitric acid	5 per cent to concentrated 95 to 212 F Good	Concentrated 65 to 185 F Excellent	Dilute—excellent Poor in concentrated at boiling
Oxalic acid	1 to 25 per cent 95 to 212 F Poor	Saturated Room to 205 F Excellent	10 to 25 per cent 70 F to boiling Poor
Phosphoric acid	1 to 85 per cent 65 to 212 F Excellent in dilute concentration at room temperature—otherwise poor	85 per cent 290 to 410 F Excellent	10 to 85 per cent 68 F to boiling Poor
Sodium chloride	3 per cent 95 F Excellent	....	5 per cent 68 F Good
Sodium hydroxide	10, 40 per cent 175 F to boiling Good	5, 40 per cent 212, 230 F Dilute—excellent 40 per cent—poor	All per cent 175 to 600 F Excellent except in dilute boiling
Sulfuric acid	5 to 65 per cent 65 to 95 F Dilute—good Concentrated—poor	20 per cent to concentrated 65 to 570 F Excellent	25 per cent to concentrated Good at 68 F Poor at high temperature
Tannic acid	25 per cent 95 F Excellent	....	....
Tartaric acid	50 per cent 95 F Excellent	....	....
White fuming nitric acid	Room temperature to 160 F Excellent	....	....

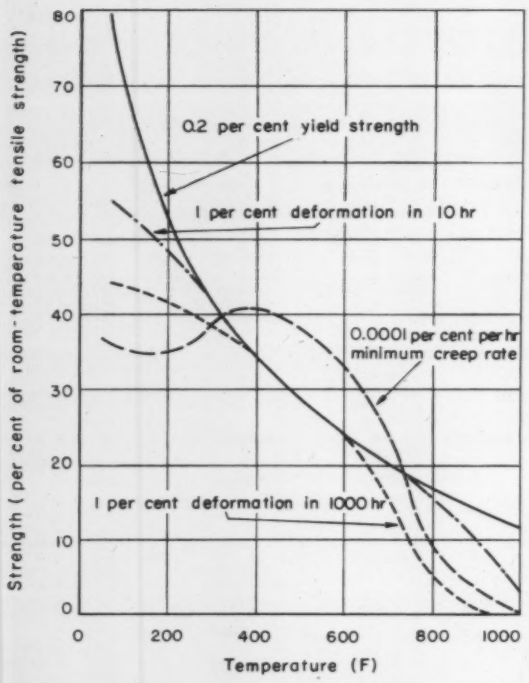
*Tabulated data, from Battelle Memorial Institute *Titanium Metallurgical Laboratory Report No.* 57, include solution concentration in per cent, temperature in deg F, and resistance to attack graded by rate of penetration per year as follows:

Excellent = Less than 0.0005 in.
Good = 0.0005 to 0.005 in.
Fair = 0.005 to 0.01 in.
Poor = More than 0.01 in.

excellent resistance to corrosive attack in sea water.

The most outstanding corrosion property of commercially pure titanium is its resistance to attack by aqueous solutions of practically all inorganic salts, particularly chlorides. Certain salts, such as ferric and cupric chloride, which cause severe pitting of other normally corrosion-resistant metals, actually will inhibit the corrosion of titanium in acid solutions. The only salt solutions that have been found corrosive to titanium are those of aluminum chloride in concentrations over 25 per cent and at temperatures over 200 F.

Commercially pure titanium has excellent corrosion resistance to nitric acid solutions over a wide range of concentration and temperature. It is also very resistant to chromic acid, and is virtually immune to hydrobromic and hydriodic acid. In dilute hydrochloric acid solutions (below 5 per cent) the corrosion rate of commercially pure titanium is low enough to be tolerated in most applications. In more concentrated hydrochloric acid solutions, corrosion of titanium is effectively inhibited by the addition of small amounts of ferric or cupric chloride salts.



Creep properties of annealed MST-55 titanium sheet

Both hydrofluoric and sulfuric acid attack titanium rapidly. However, the attack by sulfuric acid is inhibited by adding either nitric acid or ferric or cupric salts. Commercially pure titanium is exceptionally resistant to nitric-sulfuric acid mixtures over a wide range of concentration. It is also resistant to phosphoric acid in concentrations up to 30 per cent. At higher concentrations of phosphoric acid, either nitric or chromic acid will inhibit corrosion attack.

Commercially pure titanium has remarkable corrosion resistance to practically all organic compounds, including the organic acids, with the exception of oxalic acid and (under certain conditions) formic acid. It is very resistant to both monochloro and dichloroacetic acid, but not to trichloroacetic acid. It is completely resistant to most chlorinated hydrocarbons, including carbon tetrachloride, trichloroethylene, ethylene dichloride, and chloroform.

Gases: The scaling rate of commercially pure titanium in the atmosphere is low enough for most applications below 1100 F. Titanium is resistant to carbon dioxide, carbon monoxide, sulfur dioxide, and wet chlorine. It is not resistant to dry chlorine. Titanium absorbs hydrogen, causing the metal to become brittle.

Marine Environments: Commercially pure titanium has exceptional resistance to corrosion in sea water and marine environments, being superior in this respect to all other structural metals including the stainless steels and most nickel-base alloys. Titanium is also extremely resistant to impingement attack, corrosion-erosion, cavitation erosion, and crevice corrosion in sea water.

Galvanic Effects: Titanium has a noble potential similar to that of 18-8 stainless steel in aqueous media in which it is normally corrosion resistant. For this reason, when certain metals such as magnesium, aluminum, or iron are coupled with titanium in such media, the corrosion rate of these metals may be increased by galvanic action. However, in several media, especially acids, titanium has a strong tendency to polarize and therefore reduce the galvanic effects on the other metal. The galvanic effect can also be lessened by the use of various protective coatings similar to those used on stainless steels for this purpose.

They Say . . .

"The country should support—through governmental or industrial sources—all the basic research that the qualified scientists of the country will undertake. The annual expenditure could be at least doubled without danger of exceeding the limits of competent direction. In the long run, industry will benefit from a greater expenditure for basic research—and without it the applied research is in danger of stagnation." — MORROUGH P. O'BRIEN, *dean, College of Engineering, University of California, Berkeley, Calif.*

Application

Principles

Performance

Types

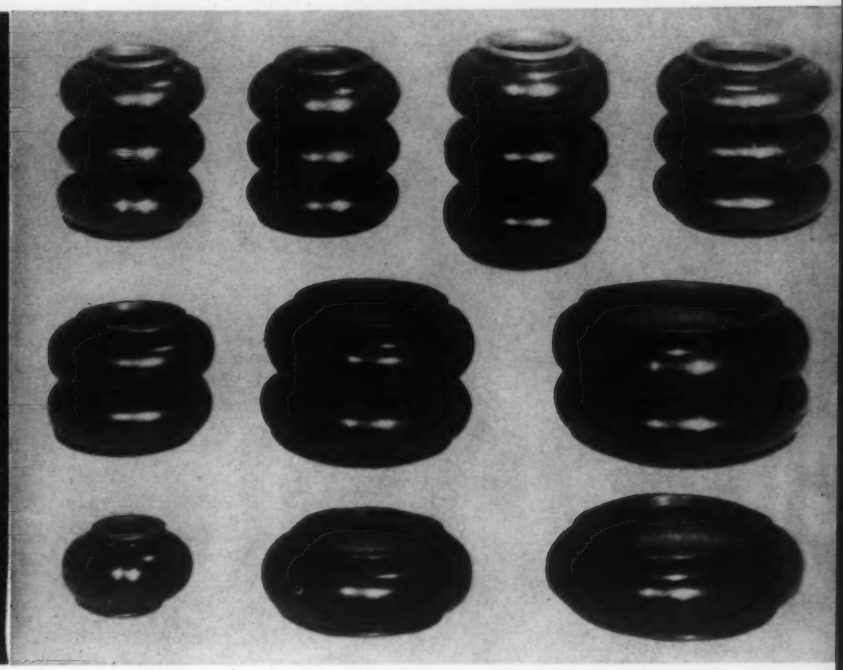
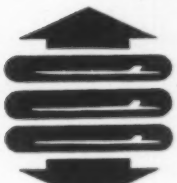


Fig. 1—Single, double, and triple-convolution air spring bellows of various sizes. This early form of the air spring is by no means obsolete, and many practical, present-day applications make use of this type of bellows.



Air Springs

By H. H. DEIST
Assistant Manager
Engineering Laboratories
The Firestone Tire & Rubber Co.
Akron, Ohio

AIR, as a load-carrying medium, is not subject to permanent set or thermal change and exhibits none of the inelastic qualities and dynamic stiffness usually associated with rubber in certain shock-absorbing applications. The excellent properties of air have caused development of the air spring to progress from the simple bellows type of Fig. 1 to a complete Airide system, Fig. 2.

Application: Early applications of the air spring were associated with passenger-car suspensions for the purpose of improving the ride. However, later developments found use in aircraft landing gear, shock and vibration isolators, pneumatic instruments, seat suspensions, valve operators, gearshift vacuum boosters, and welding-machine actuators. A successful application involved adapting air spring suspension to jet-engine shipping containers to absorb shock loads and vibration by means of bellows mounted one within the other. Fig. 3 shows a typical automotive application of rear suspension.

It is expected that an increasing number of automotive components will become air-operated as a by-product of the air suspension. Possibilities include power brakes, power steering, windshield wipers, seat adjusters, and window actuators.

Principles: The air spring as applied to vehicle suspensions has three principal features:

1. It makes possible a levelizing system which keeps the vehicle at constant standing height regardless of load. This maintains clearances when heavily loaded and requires less wheel travel and less wheel-housing clearance.

2. The air spring makes possible a suspension having very nearly the same performance in terms of softness or natural frequency regardless of load. A vehicle with air suspension rides at the

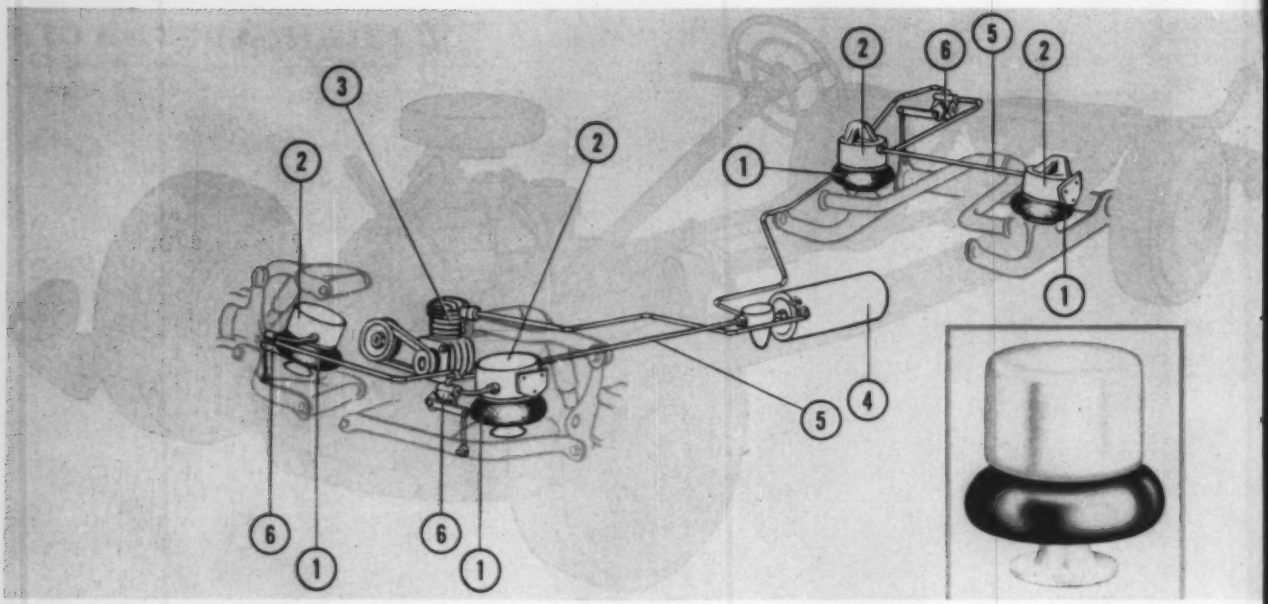


Fig. 2—Elementary air-suspension system consisting of air spring bellows, 1; reservoir, 2; air compressor, 3; air-supply tank, 4; piping, 5; and levelizing valves, 6.

same height when lightly loaded or heavily loaded.

3. Owing to its nonlinear characteristics, air spring suspension can be made to approach the ideal spring curve, i.e., a spring that is very soft in the region where it is normally used, but one that becomes progressively stiffer as it is compressed or extended.

Levelizing: The elementary air spring suspension system, Fig. 2, consists of an air compressor, a central air-supply tank, levelizing valves, reservoirs, air-spring bellows, and connecting piping. The compressor and central reservoir are operated at a pressure higher than that required for the air springs under maximum load. The function of the levelizing valve is to admit additional air to the bellows to maintain vehicle height when load is increased, or to vent excess air from the bellows when the vehicle body moves up due to unloading.

The levelizing valves force the body to remain at a fixed height regardless of load and are intended as static controls only. They adjust body height only when the load is changed and remain unaffected by dynamic forces on the vehicle. Two commonly used methods of accomplishing this are with time-delay valves and unclutching or lockout valves. In the first method, a mechanical, pneumatic, or hydraulic valve is provided with a time delay of from 1 to 20 sec duration. Time delay is sufficiently long so that transient disturbances do not cause the valve to operate, but is short enough to permit the vehicle to adjust promptly to new load conditions.

Unclutching or lockout valves are usually arranged so that they operate only when the vehicle is standing still or traveling at slow speeds. The valve lever is unclutched, or the air lines blocked, when vehicle doors are shut, when the engine runs at a certain rpm, or when the vehicle moves at a certain speed. Another method is to orifice the valves so that airflow is small and allow the valves to operate continuously. This method is simple and inexpensive but wasteful of air and slow in response.

Frequency Versus Load: Natural frequency for a spring-mass system is inversely proportional to the square root of static deflection. For systems with negligible damping and a single degree of freedom, the natural frequency, cpm, is equal to 188 divided by the square root of the static deflection in inches.

Performance of a suspension is generally measured in terms of natural frequency in cycles per minute, or in spring rate in pounds per inch of spring deflection. For linear springs, spring rate is constant throughout the stroke and a single number describes the spring. For nonlinear springs such as air springs, spring rate changes throughout the stroke, and both rate and position must be specified. With a linear-spring system, static deflection increases with load. Therefore, suspension reaction is very fast when the vehicle is lightly loaded and becomes slower when load is increased. If static deflection remains nearly the same for all load conditions, it follows that natural frequency remains almost constant which is the case with the levelizing air-spring suspension, Fig. 4.

Performance: Ideal performance for a spring of given stroke is to provide as low a frequency as possible in the range of stroke used most of the time but still be able to absorb maximum energy in compression without bottoming. Comparative performance of linear steel springs and optimum design

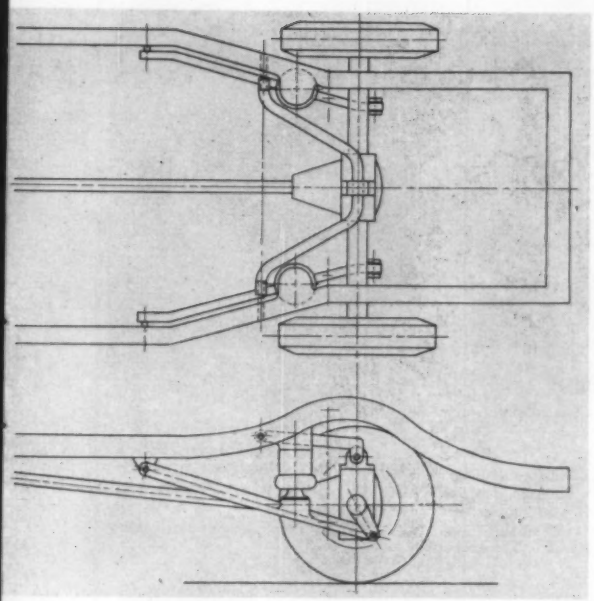


Fig. 3—Parallelogram rear suspension, trailing-arm type.

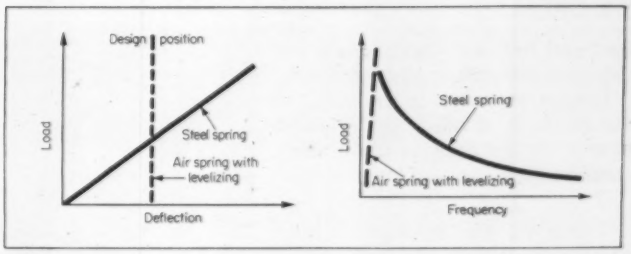


Fig. 4—Steel-spring characteristics compared to air spring characteristics. Left—Load versus deflection. For steel spring, static deflection increases with load. For air spring with levelizing, static deflection remains nearly constant for all load conditions. Right—Load versus frequency. Since static deflection is nearly constant for air springs under all load conditions, natural frequency remains almost constant.

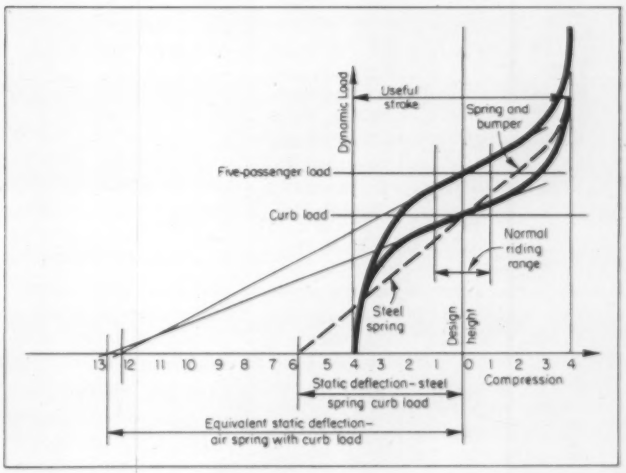

Dynamic Load
Useful stroke
Spring and bumper
Five-passenger load
Curb load
Normal riding range
Steel spring
Design height
13 12 11 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4
Compression
Static deflection–steel spring curb load
Equivalent static deflection–air spring with curb load

Fig. 5—Dynamic load-deflection characteristics of the air spring. Comparative performance of linear steel-springs is also shown. By utilizing the flat portion of the curve for normal riding range, a large equivalent static deflection is obtained for the air spring in comparison to approximately half the deflection for the steel spring.

air springs is shown in Fig. 5. Both are shown as having the same useful stroke and same design load and design height. However, static deflection of the steel spring varies from 6 in. for curb load to 8 in. for five-passenger load. The levelizing air spring maintains nearly the same static deflection for any load and, by utilizing the flat portion of the curve for the normal-ride range, a very large equivalent static deflection is obtained which results in a ride of lower frequency.

The air spring provides a ride (in the normally used portion of the curve) equivalent to that which would be produced by a linear spring having an actual stroke several times longer. Such a coil or leaf spring would, of course, be impractical. While the air spring is soft in the normally used portion of the curve, it becomes progressively stiffer when compressed, thus absorbing normal jounce energy without permitting the vehicle body to strike through to the bump stops. Shape of the air spring curve can be tailored to meet various requirements.

Definitions: The following definitions will help clarify terms used in describing types of air springs:

BELLOWS VOLUME is the internal volume of the bellows exclusive of its reservoir, if any. This volume varies with stroke, and is maximum for maximum bellows extension. It decreases to minimum at full compression. Bellows volume versus bellows stroke is shown in Fig. 6. If possible, this information should be obtained from actual test measurements but may be computed from design layout if bellows are not available.

RESERVOIR VOLUME is the volume external to the bellows when the bellows is in the fully compressed position.

EFFECTIVE AREA is the load-carrying area of the bellows. It varies with stroke, is zero at maximum extension, and is generally maximum at design position. It is best presented in terms of a curve as effective area versus stroke, Fig. 6. At any position of the bellows, effective area is equal to the load at that position divided by the air pressure at that position. Here again, this information should be obtained by actual test measurements but can be computed from design layouts using diaphragm theory if bellows are not available.

DESIGN POSITION is the position which the bellows takes under design load. Compression (jounce) and extension (rebound) are measured from the design position.

DESIGN LOAD is the load that the bellows is expected to carry normally under static conditions. A vehicle, for example, may have several design loads, such as curb

load and full load. Calculations are required for each condition.

DESIGN PRESSURE is the value of design load divided by effective area at design position under static conditions.

Types of Air Springs: A wide variety of shapes and types of air springs is available. Table 1 shows the range of size, stroke, and load characteristics of the following three types of air springs:

1. Standard - convolution bellows, Fig. 1 and 7, may have single, double, or triple convolutions. This bellows has the characteristic that effective area increases from zero at maximum extension to maximum at full compression, while volume decreases from maximum at maximum extension to minimum at full compression. Typical dynamic performance curves are shown in Fig. 8.
2. Single-convolution bellows, Fig. 9 and 10, lends itself to low frequencies with minimum reservoir size since the bellows has a small volume, yet permits a long stroke. In addition, effective area can be made to decrease with compression to offset the influence of increasing air pressure. Degree of change in effective area can be controlled by the shape of the lower attachment or pedestal. Several of these shapes are illustrated in Fig. 11. Complete freedom in choosing a pedestal shape is limited by flexing life and stability considerations.
3. Double-convolution bellows, also Fig. 9 and 10, is basically similar to the single-convolution type but permits even longer strokes. Fig. 6 illustrates typical dynamic performance curves for types 2 and 3.

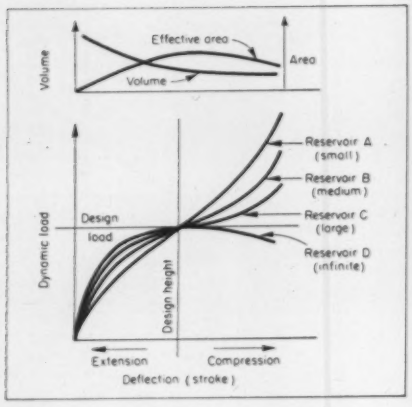


Fig. 6—Performance characteristics of single and double-convolution type of air springs shown in Fig. 9 and 10. Bellows volume and effective area are shown as functions of stroke.

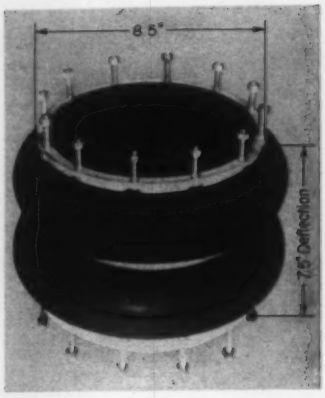


Fig. 7—Standard-convolution bellows for heavy-vehicle suspensions. This 6-lb unit sustains a 7000-lb load. This type of bellows may have single, double, or triple convolutions.

Air Spring Theory: Performance characteristics of an air spring are determined by two factors. The first is the expansion and compression of air as the bellows extends or compresses, and the second is the change in effective area throughout the total stroke. Since rubber is a good thermal insulator, dynamic expansion and compression of the air is essentially adiabatic. Change in effective area is inherent in the design of the various types of air-spring bellows.

Load-Deflection Calculation: Dynamic load-deflection is calculated as follows: Calculate design pressure for design position from

$$L_D = (P_D - 14.7)A_D \qquad (1)$$

Relate volume to deflection, and effective area to deflection from

$$V_X = V_0 - BX \qquad (2)$$

$$A_X = CXe^{-KX} \qquad (3)$$

Nomenclature

A	= Effective area, sq in
B, C, K	= Constants
L	= Dynamic load, lb
P	= Absolute pressure, psi
V	= Bellows volume, cu in.
V_R	= Reservoir volume, cu in.
X	= Deflection from extended position, in.
γ	= Polytropic coefficient

Subscript D in equations denotes design position.

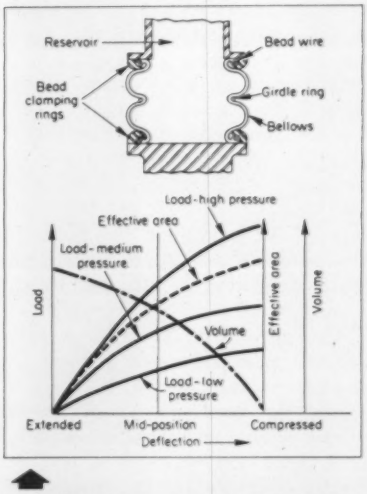


Fig. 8—Dynamic performance characteristics of standard-convolution bellows. Effective area increases from zero at maximum extension to maximum at full compression. Volume decreases from maximum at full extension to minimum at full compression.

Table 1—Characteristics of Air Springs

	Type of Air Spring		
	Single Convolution	Double Convolution	Triple Convolution
Max recommended air pressure at mid-position, 2-ply construction*, psi	75	75	75
Max stroke, in.	4	9	12
Min effective area at mid-position, sq in.	14	15	18
Max effective area at mid-position, sq in.	276	160	160
Rated load at mid-position, max size, lb	20,800	12,000	12,000
Rated load at mid-position, min size, lb	1,050	1,125	1,350

*Higher pressures are possible with increased ply.

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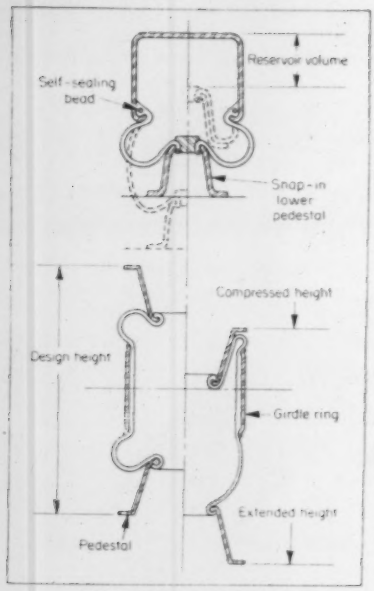

Equations 2 and 3 are typical of these relationships for single-convolution bellows. Constants must be determined for each size bellows. Calculate dynamic load-deflection values from

$$L_X = \left[P_D \left(\frac{V_0 - B_D + V_R}{V_0 - BX + V_R} \right)^{\gamma} - 14.7 \right] CXe^{-AX} \qquad (4)$$

and plot load-deflection curves as shown in Fig. 5. Repeat for various reservoir sizes.

Fig. 9 — Cross-sections of bellows shown in Fig. 10. Top—Single-convolution bellows has unequal bead diameters for effective sealing at reservoir connection. Bottom—Double-convolution bellows similar to single-convolution type but permits longer strokes.

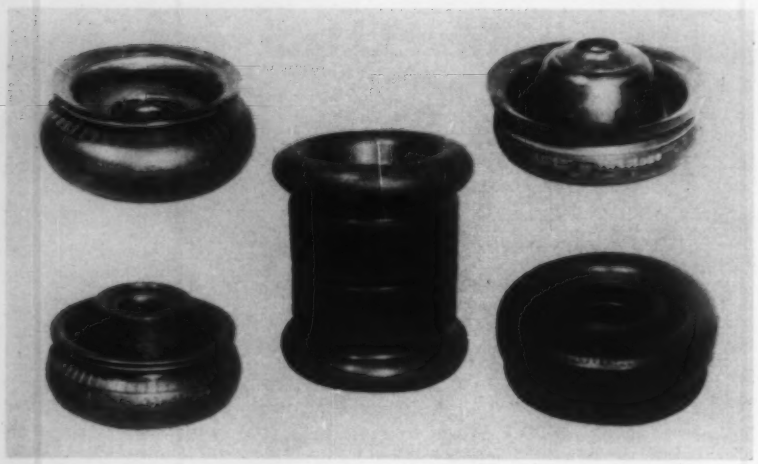

Fig. 10—Single and double-convolution bellows. These types lend themselves to low frequencies with minimum reservoir size since the bellows have small volumes.

Obtain equivalent static deflection for any chosen curve and any part of the stroke by constructing a tangent to the curve at that point and measuring the intercept on the abscissa as shown in Fig. 5 to obtain natural frequency of the air spring.

From a paper entitled "Development of Air Springs and Their Application to Automotive, Aircraft, and Industrial Uses," presented at a joint session of the Rubber and Plastics, Railroad and Materials Handling Divisions at the ASME Annual Meeting in New York, December, 1957.

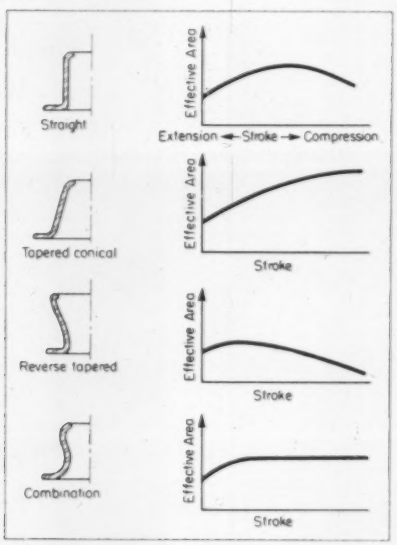

Fig. 11—Influence of pedestal shape on effective-area change. Freedom in choosing a pedestal shape is limited by flex life and stability conditions.

Preparation of magnesium parts for *Dip Brazing*

By WILLIAM J. GRAVES
Engineering Department
Dalmo Victor Co.
San Carlos, Calif.

DIP brazing is a method of joining metallic parts by submerging them in a molten-flux bath whose temperature is below the melting point of the parts to be joined but above the melting point of the brazing or filler alloy. Magnesium dip brazing is somewhat similar to aluminum dip brazing in that parent metal base filler alloys as well as chloride-base fluxes are used.

Preparation of parts for magnesium dip brazing consists of the following steps:

1. Parts must be free from burrs because they restrict flow of molten filler-alloy.
2. Clean parent-metal parts and filler metal by either degreasing or lightly sanding with Aloxite cloth. Follow with a hot-water rinse and air dry. Several Dow treatments may also be used.
3. Assemble parts in a brazing fixture with filler metal in place. Clearance for filler-metal flow ranges from 0.004 to 0.006 in. per side depending on the size and length of the brazed joint. Prebraze assembly methods include spring-loaded fixtures and tack welding. It is important that

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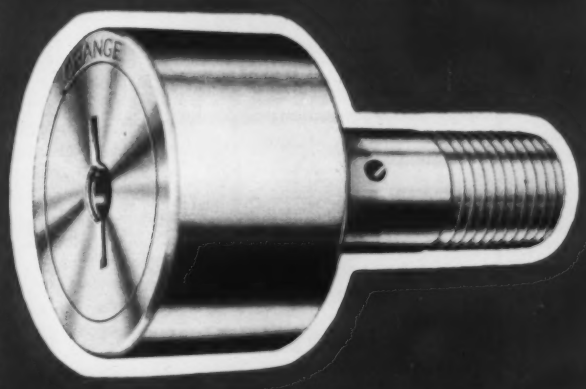

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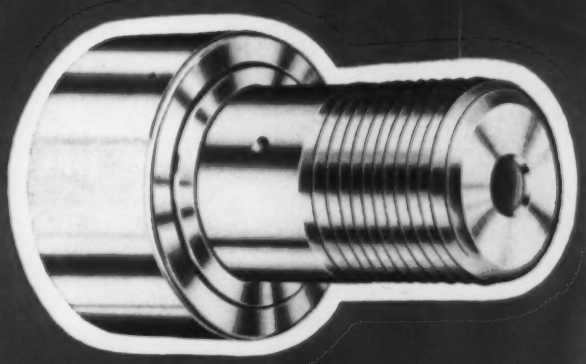

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M1A alloy welding rod be used for tacking. Filler metal shims and wires may be formed and/or stamped from stock. Filler metal AZ125 is somewhat brittle but, with proper handling, simple forming can be accomplished.

4. Preheat the assembly in an oven at 850 F. Heating accomplishes evaporation of moisture from the assembly and reduces heat loss of the flux bath.
5. Remove assembly from the oven and immerse immediately in the flux bath. Immersion time varies from ½ to 3 min depending on the mass of the assembly. Immersion time should not be any longer than necessary to accomplish complete filler metal flow. Alloying of the filler and parent metals results in undercutting around the brazed joint.
6. Remove the assembly, allow to cool to 600 F. and then plunge it into boiling water to remove the bulk of frozen flux. Dip for 1 min in Dow No. 1 solution and subject the assembly to a boiling 5 per cent solution of sodium dichromate for 2 hr.
7. Fixtures, if needed, should be kept to minimum size and weight consistent with parts positioned. Excess mass contributes to reduction of flux-bath temperature and increases amount of flux drag-out.
8. Flux drainage requires simple fixture designs to facilitate fast, complete drainage. Flux entrapment in blind holes and closed cavities is detrimental to the assembly. Free flow of water across joints is essential.
9. Dip-brazing fixtures should be of stainless steel or high-content chrome steel to resist corrosive action of the flux bath.

The difference between the expansion of magnesium parts and steel fixtures must be given careful consideration at the design level. The fixture must maintain proper positioning of parts and, at the same time, allow for the expansion differential during the preheat and brazing cycles.

Preliminary tests indicate that a shear strength of from 12,000 to 14,000 psi for a lap-joint brazement may be expected. A great number of brazements of various configurations have been subjected to an internal pressure of 35 psi. Percentage of leaks has been less than ¼ of 1 per cent. An x-ray examination of typical brazements showed no cracks and very little or no porosity or voids. With careful design, slight porosity or voids present no problems.

From a paper entitled "Dip Brazing of Magnesium—Possible, Practical, and Efficient," presented at the Magnesium Association Meeting in New York, October, 1957.

Thermocompression Bonding

By O. L. ANDERSON
Mechanics Research
Bell Telephone Laboratories
New York, N. Y.

A RELATIVELY new technique, known as thermocompression bonding, joins metals to nonmetallic materials. Developed for adhesion-bonding of electrical leads to semiconductors like germanium and silicon, the technique promises strong, reliable bonds between extremely small areas without using chemical fluxes and melting.

Thermocompression bonding, distinct from soldering and cold welding, has the following practical features:

1. Bonds can be made quickly in open air without chemical fluxes.
2. Pressures used are so low that no change in mechanical or crystal structure of the semiconductor can be detected.
3. Temperatures used are so low that no evidence of diffusion of the metal into the semiconductor can be detected, nor is there any melting.

The connection, made at minimum cost without adversely affecting electrical performance, has the ultimate in strength since the strength of the bonded region exceeds that of the wire used for connection.

As in Fig. 1, the bond is made simply by pressing metallic wire against a heated semiconductor. Wires of gold, copper, silver, aluminum, platinum, tin, and lead, as well as a number of alloys of these metals, have all been bonded to both germanium and silicon. Heretofore, applications of this method were limited because gross seizure between most metals was observed to occur only in vacuum. Outside a vacuum, applications were limited because one of the solids had to be excessively soft material like indium.

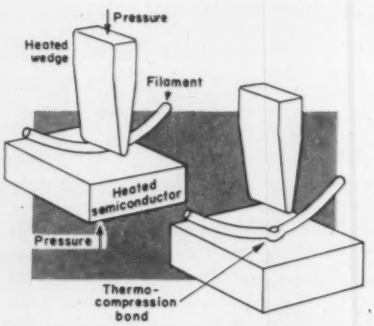

Fig. 1—Method of making a thermocompression bond. Bonding time varies from 5 sec to 10 min at pressures from 5000 to 10,000 psi and temperatures from 392 to 572 F. This technique makes possible the attachment of wire leads to brittle nonmetals like silicon and germanium.

Bonding is most successful when the metallic filament is very soft. A hard, noble metal, like platinum, is more difficult to bond than a soft, base metal like aluminum, but very pure platinum, made about as soft as aluminum, will adhere easily.

Resistance measurements between gold and germanium show that when adhesion occurs, resistance across the junction drops by a factor of about ten, indicating that the oxide film separating the two solids is pierced.

The thermocompression bond requires some application of heat, but under the right conditions, metal-to-metal adhesion can be established at room temperature.

From "Adhesion of Solids: Principles and Applications," presented in Bell Laboratories Record, *Vol.* 35, *No.* 11, *November,* 1957.

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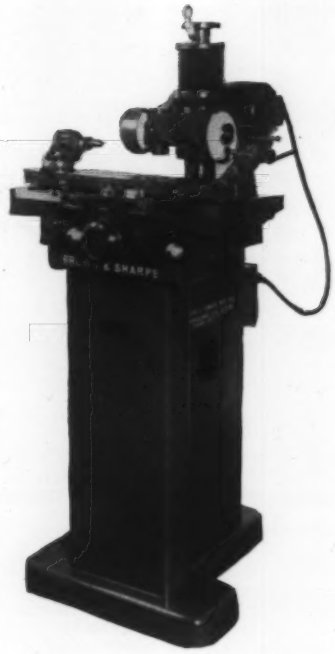

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Circulating Oil System

The Mark II Meterflo circulating oil system controls flow of oil in the moderate volume range to multiple outlets regardless of varying back pressures or change in oil viscosity. Bulletin 574 provides essential design information. Trabon Engineering Corp., 28815 Aurora Rd., Solon, Ohio. F

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Variable Transformers

First model in line of variable transformers is described in Bulletin 151. This Model VT1R5 has continuous current rating of 1.5 amp at any brush setting, even full overvoltage. 2 pages. Ohmite Mfg. Co., 3668 Howard St., Skokie, Ill. J

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Flexible Couplings

Bulletin 10100 tells how to select Sure-Flex flexible couplings for over 150 different service applications. Five tables aid in making calculations. Coupling withstands all combinations of misalignment and end float and will absorb up to 15 degrees torsional shock. 8 pages. T. B. Wood's Son Co., Chambersburg, Pa. E

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Transistor Don'ts

"Real mad" cartoon treatment in this booklet conveys information on how not to use transistors. Booklet proves invaluable reading at coffee break time, according to company release. General Transistor Corp., 91-27 138th Place, Jamaica, N. Y. D

Circle 578 on Page 19

High Strength Steel Plates

Clay-Loy high strength steel plates used in construction and marine equipment are stronger than equivalent carbon steel plates, have excellent welding properties, and are more resistant to atmospheric corrosion, according to descriptive folder. 4 pages. Colorado Fuel & Iron Corp., 575 Madison Ave., New York, N. Y. K

Circle 579 on Page 19

Super Alloy Fasteners

Technical data sheet covers uses of new bolts and rivets of super alloys for high temperature applications in jet engines, airframes and guided missiles. It gives performance characteristics along with A.M.S. specifications. 2 pages. Techalloy Co., Rahns, Pa. E

Circle 580 on Page 19

Steam Thermostats

Models SC and ST rod-and-tube steam thermostats provide sensitive throttling control for coffee urns, dish washers, sterilizers, and steam tables in temperature range between 185 and 220° F. Descriptive Bulletin RT-818 offers cut-away and installation diagrams. 4 pages. Robertshaw-Fulton Controls Co., Robertshaw Thermostat Div., Youngwood, Pa. E

Circle 581 on Page 19

Catalytic Protective Coatings

Wide industrial usage of IFCO catalytic protective coatings is pointed up in brochure. Coatings feature tremendous adhesion and wear resistance, one coat application in most cases, immunity to humidity and water, 5 to 10 minute air drying, and corrosion and heat resistance. 8 pages. Industrial Finishes Co., 1119 Land Title Bldg., Broad & Chestnut Sts., Philadelphia 10, Pa. E

Circle 582 on Page 19

Cabinet Racks & Desks

Specifications, prices, and descriptions relative to Par-Metal universal cabinet racks and utility desk assemblies are given in Catalog 58. Booklet emphasizes design flexibility of this equipment. New 30-in. wide panel racks are included for the first time. 28 pages. Par-Metal Products Corp., 32-62 49th St., Long Island City 3, N. Y. D

Circle 583 on Page 19

Force Control Switches

Much design data are packed into illustrated Bulletin 49E on force control switches. Units are furnished with one to four adjustable switches for controlling forces at many load points. Capacities from 0-100 to 0-50,000 lb are available. 2 pages. W. C. Dillon & Co., 14620 Keswick St., Van Nuys, Calif. L

Circle 584 on Page 19

Optical Aids

The over 1000 optical items listed in this optical catalog include industrial quality control tools for measuring and checking, surplus optical items, and imported instruments. Hundreds of illustrations are provided. 80 pages. Edmund Scientific Co., Barrington, N. J. D

Circle 585 on Page 19

Pulse Transformers

Specifications on complete line of pulse transformers are listed in latest general Catalog TR-57. Twenty-five new items added to line are included in the listing. Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif. L

Circle 586 on Page 19

Silicon Solar Batteries

A new series of silicon photovoltaic cells for converting light energy into electric power is briefly described in Bulletin SR-156. Engineering data include spectral response, output voltage, output power, electrical characteristics, and temperature range graphs. 2 pages. International Rectifier Corp., El Segundo, Calif. L

Circle 587 on Page 19

Environmental Test Equipment

Equipment for environmental testing, metal treating, preserving chemicals and biologicals, research, and production testing is described in loose-leaf brochure. Essential tabular data are included. Equipment simulates humidity, temperature, altitude, sand and dust, fungus, rain and sunshine, and explosion conditions. 22 pages. Environmental Equipment Corp., 369 Linden St., Brooklyn 27, N. Y. D

Circle 588 on Page 19

Electrical Connectors

High breakdown voltage between pins and ground is featured by CEC high-performance miniature electrical connectors for extreme environmental applications. Bulletin 4003 describes these connectors and gives application and dimensional information. 4 pages. Consolidated Electrodynamics Corp., Glendale Div., 740 Salem St., Glendale 3, Calif. L

Circle 589 on Page 19

Belleville Springs

Typical end uses for Belleville springs are cited in technical bulletin on these spring cartridges. Formulas and design data are included for original equipment as well as for maintenance and replacement use. 16 pages. Union Spring & Mfg. Co., Second Avenue & Eighth Street, New Kensington, Pa. F

Circle 590 on Page 19

Hydraulic System Analyzer

Industrial Engineering Bulletin 24 provides technical and other data on the Hydrauliscope. This electronic analyzer utilizes oscilloscopic principles to measure pressure activity and phenomena in hydraulic systems. 4 pages. Aeroquip Corp., Jackson, Mich. H

Circle 591 on Page 19

Brazing & Welding Products

A new all-purpose, low-fuming, manganese-bronze filler rod known as AMPCO-BRaZ No. 2 is latest of a complete line of Weldrod products described in Bulletin W-17. Ampco Metal, Inc., 1735 S. 38th St., Milwaukee 46, Wis. K

Circle 592 on Page 19

Synthetic Resin Products

Scotchcast resins for potting, insulating, coating, and impregnating of electrical products are discussed in Folder E-EPS. Pot life, cure, type, and application of rigid and flexible

AVOID the
HIGH COST
and difficulty
of fabricating
long, hard
& straight parts
by conventional
methods . . .

THOMSON

60 Case

hardened and ground

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

60 Case is the result of over ten years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining.

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ADVANTAGES of *60 Case*

- COST REDUCTION
- HARD BEARING SURFACE
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

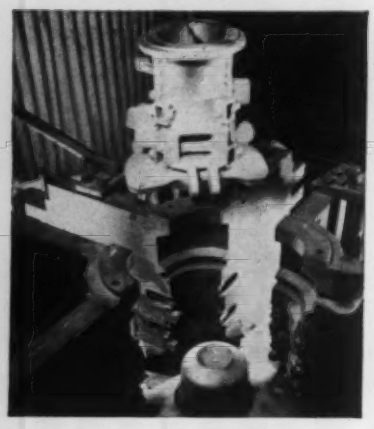
GUIDE RODS, SHAFTING, ROLLS, TRAVERSE RAILS, PISTON RODS, ARBORS, LEADER PINS, TIE RODS, KING PINS, AXLES, CONTROL RODS, GUIDE POSTS, MANDRELS, BEARING ROLLERS, SPINDLES

THOMSON INDUSTRIES, Inc.
Dept. C-5, Manhasset, New York

Circle 472 on Page 19

NEW DESIGN OPPORTUNITY

With Monarch Aluminum Permanent Mold Castings



Modern methods in mold designing—metallurgy—and mass production operations make Monarch Permanent Mold Castings more versatile to fully meet today's end-product requirements competitively.

From complicated industrial castings to finished consumer product castings, ready for assembly, Monarch's wide range of services offer "More Casting Value per Dollar".

This new approach to casting evaluation and "One Source" production in permanent mold–Aluminum Die Casting and Zinc Die Castings is presented in a new brochure, "Manufacturing Achievements in Molten Aluminum". Write for Your Copy Today.

MANUFACTURING ACHIEVEMENTS in MOLTEN ALUMINUM

MONARCH ALUMINUM MFG. COMPANY

9205 Detroit Avenue Cleveland 2, Ohio

Circle 473 on Page 19

Helpful Literature

resins, inorganic potting compounds, and resin impregnated tapes are shown. 4 pages. Minnesota Mining & Mfg. Co., St. Paul 6, Minn. J

Circle 593 on Page 19

Frequency Measurements

"Frequency Measurements and How to Make Them" is title of Data File III on EPUT and frequency meters. It covers measurement of low to UHF frequencies, rotational velocity, flow, pressure, temperature, and strain, as well as telemetry and setting up a secondary standard of frequency. 18 pages. Beckman/Berkeley, Dept. 7258, 2200 Wright Ave., Richmond 3, Calif. L

Circle 594 on Page 19

Precision Potentiometer

Details of a new Helipot Series 5000, ½-in. single-turn, precision potentiometer are presented in Preliminary Data Sheet 54-99. Features include −55 to 150° C temperature range and resistance of 500 to 70,000 ohms with linearity tolerance of ±0.5 per cent. 4 pages. Beckman Instruments, Inc., Helipot Div., Newport Beach, Calif. L

Circle 595 on Page 19

Lifting Winch

Model 61 winch with self-contained motor and lifting capacity of 6000 lb is subject of pocket-size booklet. Reel-in rate is 10 fpm at capacity load. Specifications are included. 4 pages. All American Engineering Co., Box 2668, DuPont Airport, Wilmington 5, Del. C

Circle 596 on Page 19

Steel Tubular Products

Points to consider in selecting steel tubing or pipe for process applications are outlined in illustrated Bulletin TB-417. Properties of seamless and welded tubing and pipe, welding fittings and forged flanges are given, and typical applications are shown. 16 pages, Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. C

Circle 597 on Page 19

Plastics

"1958 Condensed Reference File" describes the major families of plastics produced by Bakelite, including polyethylenes, vinyls, styrenes, phenolics, and epoxies. Details and applications of each are presented. 12 pages. Bakelite Co., 30 E. 42nd St., New York 17, N.Y. C

Circle 598 on Page 19

Automation Controls

Wide selection of automatic controls used in designing automatic systems is covered in illustrated catalog "Automation Controls." Included are counting devices, switches, electric valves, actuators, relays, limit controls, and time switches. General Controls Co., 801 Allen Ave., Glendale 1, Calif. L

Circle 599 on Page 19

Blueprint Racks

Glider 700 modular vertical blueprint file is described and illustrated in illustrated folder. It shows how the 2 x 2 x 4-ft steel unit holds plans

UNIQUE "ONE SOURCE" CASTING ANALYSIS

Offers "More Casting Value Per Dollar" in Monarch

✔ALUMINUM PERMANENT MOLD

✔ALUMINUM DIE CASTING

✔FUNCTIONAL ZINC DIE CASTING

Effective value analysis requires experienced judgement and knowledge of all methods involved. Years of experience in design and production of aluminum permanent mold, aluminum and zinc die castings, ready for assembly—enables Monarch to give you factual costs and impartial design analysis.

SaveTime. Save Money. Contact Monarch on your casting requirements. Monarch produces the finest castings that can be made by each method. Send today for our new brochure—"Manufacturing Achievements in Molten Aluminum".

MANUFACTURING ACHIEVEMENTS in MOLTEN ALUMINUM

MONARCH ALUMINUM MFG. COMPANY

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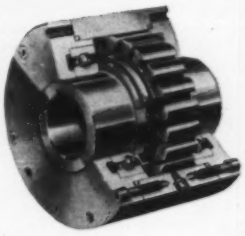
Circle 473 on Page 19

The Solution To Your Clutch Problems Is On This Page . . .

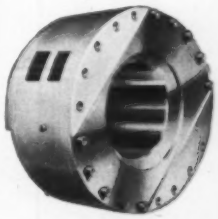
- OVER-RUNNING (FREE WHEELING)
- BACKSTOPPING (HOLDBACKS)
- INDEXING (RATCHETING)

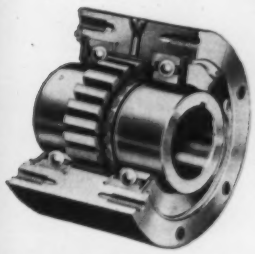
Formsprag patented clutches are built around the sprag principle. Sprags are precision manufactured wedges which increase efficiency and prolong clutch life. The sprag clutch takes the place of old-fashioned roller or ratchet types. Because a sprag has greater contact surface than a roller bearing against the outside and inside races, a Formsprag clutch has increased torque capacity. These sprags engage automatically at constantly changing contact points and—unlike old-type clutches—cannot backlash or slip. This same feature prolongs clutch life. Right now Formsprag clutches are serving industry in every field from aircraft to business machines. Special models available if standard models are not suitable in your application.



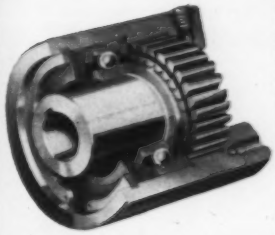
BALL BEARING HIGH SPEED CLUTCH. SERIES "A". . .
for continuous high speed overrunning, employs a labyrinth-type oil seal which prevents overheating, excessive wear. Bore diameters. 2½" to 5½"; torque capacity: 1875 to 11,600 ft.-lbs.

LARGE BORE BACKSTOPS . . .
ideal for mounting on head shafts of large outdoor conveyors. Features high torque to weight ratio. Mechanically sealed against dirt and moisture and adaptable to high efficiency over-running. Bore diameters: 6" to 12"; torque capacity 18,500 to 136,500 ft.-lbs.





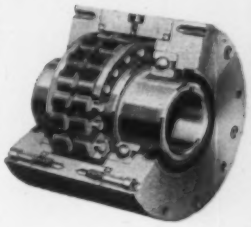
BALL BEARING ALL PURPOSE CLUTCH . . .
designed for maximum accuracy and long life, is ideal where prolonged over-running, or rapid indexing is desired Bore diameters ¼" to 2¼", torque capacity 95 to 1900 ft.-lbs.



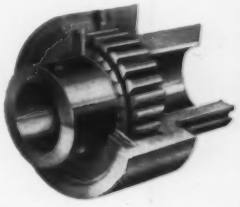
SPECIAL PURPOSE BALL BEARING CLUTCH . . .
designed for end-shaft applications Basically for indexing, but may be used for over-running and backstopping. Requires snap-ring bearing insertion, seal; shaft end must be turned down and threaded for bearing and lock nut. Bore diameters. ⅜" to 2", torque capacity 60 to 295 ft.-lbs.

MODELS FS-02 AND FS-04 . . .
light-duty, highly accurate, compact clutches, designed to transmit maximum torque where space is at a minimum. They are ideal for business machines, home appliances and small industrial machines. Provision for mounting components. Bore diameters: ¼" to ½"; torque capacity: 50 to 200 in.-lbs.

BALL BEARING SEALED CLUTCH, SERIES "B" AND "C" . . .
incorporate mechanical seals to retain oil on low speed applications, exclude dirt and moisture. For true over-running use series B; for indexing or backstopping, series C. Bore diameters. 2¼" to 5½"; torque capacity: 1875 to 11,600 ft.-lbs.



SLEEVE BEARING CLUTCH . . .
designed for moderate speed applications where loads are not excessive Generally considered most suitable for use where surrounding mechanism is mounted in sleeve bearings rather than in anti-friction bearings. Bore diameters ⅜" to 2" torque capacity 10 to 1310 ft.-lbs.



CLUTCH-COUPLING UNITS . . .
designed for use in coupling two shafts when over-running application is desired. Available in two basic units the smaller size is designed on the basis of bore size for light jobs. The larger is for heavy duty and high torque applications. These clutch couplings use ball bearing clutches FS-400—FS-1000. Bore diameters of coupling. 1" to 7"; torque capacity 21 to 12,079 ft.-lbs. Bore diameters of clutch: ¾" to 5½".

FORMSPRAG COMPANY

World's largest exclusive manufacturer of over-running clutches

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58-K

Circle 474 on Page 19

NOW, A STANDARD LINE OF DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-V, which includes drawings and full specifications.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet, Screw,
Hydraulic, Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever
Spur Gear, Electric

Circle 475 on Page 19

Helpful Literature

from 18 to 24 in. wide without need for hole-punching. 6 pages. Momar Industries, 4323 W. 32nd St., Chicago 23, Ill. I

Circle 600 on Page 19

Air Compressors

Waukee air compressors described in illustrated Bulletin 430 have a built-in automatic bypass regulator and are offered in 12 ranges from 400 to 6000 cfh at 1 to 3 psi. Construction features, specifications, and a capacity table are included. 2 pages. Waukee Engineering Co., 5138 N. 35th St., Milwaukee 9, Wis. K

Circle 601 on Page 19

Heat Transfer Equipment

Nocordal impervious graphite heat transfer equipment for corrosive chemicals is subject of illustrated Bulletin 156. Covered are heat exchangers, immersion heaters, and jet agitators. Specifications and engineering drawings are included. 4 pages. Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland 11, Ohio. F

Circle 602 on Page 19

Plastic Molds & Molding

"Engineering in Plastics" is title of illustrated folder which describes company's mold making and custom molding services. Extent of services is covered and many molded parts produced are shown. 4 pages. V. H. Swenson Co., 552 Elm St., Arlington, N. J. K

Circle 603 on Page 19

Power Supplies

Regulated and unregulated transistorized power supplies are described in folder. Ac to dc, dc to dc, and dc to ac equipment is covered. 4 pages. Hyperion, Inc., 1449 Washington St., West Newton, Mass. B

Circle 604 on Page 19

Pressure Transmitter

Force-balance differential pressure transmitter featuring measuring parts sealed off in silicone oil and adjustable damping within the measuring circuit is subject of illustrated Catalog 10B1465. Operation is described and specifications are given. 4 pages. Fischer & Porter Co., 490 Jacksonville Rd., Hatboro, Pa. E

Circle 605 on Page 19

Microwave Components

Ten specifications sheets with diagrams, photos, descriptions, and physical and electrical characteristics of various microwave relay components in the WR-137 waveguide size are contained in this brochure. Parts from transmitter to antenna are covered. Airtron, Inc., 1096 W. Elizabeth Ave., Linden, N. J. D

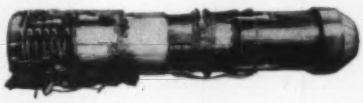
Circle 606 on Page 19

Air Moving Ratings

Specifiers of centrifugal, axial, and propeller fans, and power roof ventilators are given aid in identifying air moving equipment certified to perform according to published performance ratings by Technical Bulletin 153-57. It contains certified ratings and typical test set-ups and performance curves. Air Moving &

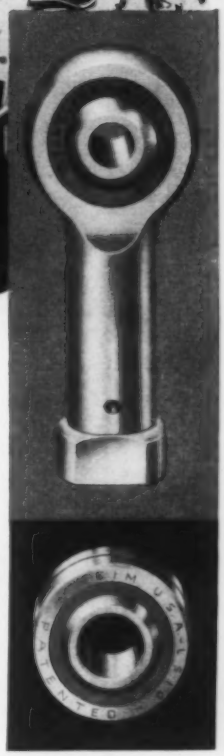
HEIM *Unibal*® Rod Ends

...in good company...



The new General Electric J79 jet engine has the highest thrust-to-weight ratio of any aircraft power plant in production. The engine is rated in the 10,000-pound thrust class.

Variable stators are used for the first time in a flying jet engine, which in a mechanically simplified way, and with far less weight, accomplish the same thing that the dual rotor does in other current engines. The device provides a smooth flow of air inside the engine and eliminates the "stall barrier" problem.



HEIM UNIBAL SPHERICAL BEARINGS and ROD ENDS supply the exact type of linkage, mounting, and degree of misalignment correction required by this engine, and The Heim Company is proud of its contribution to the success of the GE J79.

There are over 200 Unibal Rod Ends assembled with the variable pitch stator blade operating levers.

There are over 50 LS type Unibal Spherical Bearings used as pivot points for the inlet guide vanes.

The bearings which mount the engine to the airframe are three Heim Unibal cartridge units. These bearings carry the entire weight of the engine *and its thrust*.

Other Heim bearings of various types used on this engine bring the total to around 500.

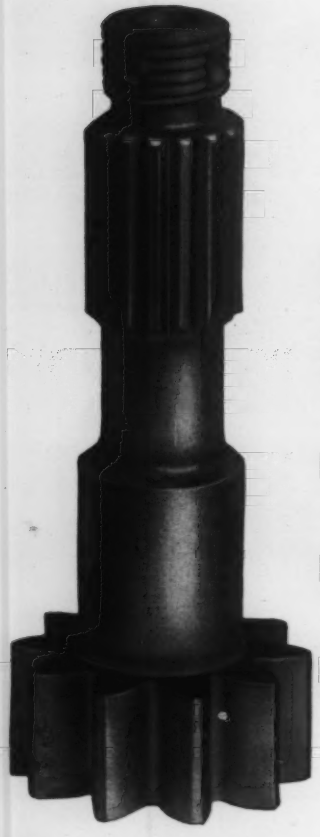
* * * *

The load carrying capacity of Unibal spherical bearings is very high. They are applicable in any linkage where motion must be transmitted at constant or varying angles. They are ideal as supports to any device which is subject to mechanical or thermal deflection.

COMPLETE CATALOG AVAILABLE / SOLD THROUGH THE LEADING BEARING DISTRIBUTORS

THE HEIM COMPANY, FAIRFIELD, CONNECTICUT

Circle 476 on Page 19



WHY TRY TO SOLVE YOUR GEAR PROBLEMS ALONE?

PERKINS can custom-cut a precision gear to fit your exact needs... make you a gear that guarantees full capacity and trouble-free performance. Many gear-makers promise a precision gear — Perkins delivers precision . . . always. Fifty-two years of gear-making for aircraft, automotive and instrument manufacturers assure top quality. Extensive facilities, modern equipment, rigid production and quality controls produce gears consistently uniform in tolerance with a burr-free micro finish. Perkins quality eliminates production delays and costly rejects for you .... Perkins gears wear longer, cost you less in the long run. Ask us to quote on your next gear requirement. Then judge for yourself.

YOURS ON REQUEST Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

Dept. 33, West Springfield, Mass.
Telephone: REpublic 7-4751

Helpful Literature

Conditioning Association, 2159 Guardian Bldg., Detroit 26, Mich. H
Circle 607 on Page 19

Dry Film Lubricants

EverLube, a hard, dry, permanently bonded lubricative coating, is subject of illustrated brochure. It is used on threads, gears, slides, bushings, hinge pins, cams, springs, etc. Application data are presented. 8 pages. EverLube Corp., 6940 Farmdale, North Hollywood, Calif. L
Circle 608 on Page 19

Switches

Toggle and trigger switches in line of 10 standard types are described and illustarted in Catalog 100-1. Dimensions and electrical ratings are given for the UL-approved units for small motors and appliances. 2 pages. Sargent Electric Corp., 630 Merrick Rd., Lynbrook, N. Y. D
Circle 609 on Page 19

Transmission Lines

Bulletin for air dielectric RETMA coaxial transmission line and components contains prices for extensive line of units. Lines are made to RETMA standard dimensions for conductors, flanges, and connectors. 8 pages. Prodelin Inc., Kearny, N. J. D
Circle 610 on Page 19

Jib Cranes

Engineering drawing and a table of dimensions in catalog sheet provide needed information for selection of base-mounted jib cranes. Crane capacity, boom lengths, and height of lift are given for 500 to 10,000-lb capacity units. Becker Crane & Conveyor Co., 4900 Ridge Rd., Cleveland, Ohio. F
Circle 611 on Page 19

Straight Thermometers

Line of straight form thermometers for use on top of tanks and boilers is described and illustrated on Data Sheet 51 E. Ten Fahrenheit or Centigrade ranges are offered in various stem lengths and dial diameters. 2 pages. W. C. Dillon & Co., 14620 Keswick St., Van Nuys, Calif. L
Circle 612 on Page 19

Tachometers & Tachoscopes

Design features, specifications, and application data for improved, direct-reading Tachoscope chronometric tachometers and hand tachometers are content of illustrated bulletin. Tachoscope is offered in several models with ranges from 0-20,000 to 0-200 rpm. 4 pages. O. Zernickow Co., 15 Park Row, New York 38, N. Y. D
Circle 613 on Page 19

Tube Fittings

Flareless type Ferulok tube fittings for ⅛ to 2-in. diameter tubing are fully detailed in Catalog 4320. Complete design and application data are tabulated. 28 pages. Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio. F
Circle 614 on Page 19

Printed Circuit Connector

Specifications, diagrams, and data on the Continental Series 683 printed

Circle 477 on Page 19

Helpful Literature

circuit connector with right angle pins and polarizing screwlocks are found in data sheet. Mounting dimensions are given. 2 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 615 on Page 19

Quick-Opening Fasteners

Three separate lines of Q-1, Q-2, and Q-4 quarter-turn, quick-opening fasteners are presented in illustrated Catalog AF-1. Dimensional data, installation instructions, and where-to-use information are included. 24 pages. Illinois Tool Works, Fastex Div., 195 Algonquin Rd., Des Plaines, Ill. J

Circle 616 on Page 19

Mechanical Steel Tubing

Bulk of catalog on mechanical steel tubing is devoted to tables showing size range, cutting, and size tolerance of round tubing; and size ranges, radii of corners, and tolerances of square and rectangular tubing. 12 pages. Sharon Steel Corp., Brainard Steel Tubing Div., Griswold St., Warren, Ohio. G

Circle 617 on Page 19

Laminated Plastics & Fiber

Photos, descriptions, and data tables in this catalog aid in selecting and applying laminated plastics and vulcanized fiber to electrical and mechanical components. First section covers over 50 grades of laminated plastics, including copper-clad laminates, and second section lists 10 grades of vulcanized fiber. 8 pages. Taylor Fibre Co., Norristown, Pa. E

Circle 618 on Page 19

Ballizing Fixture

Wide range of parts for ballizing holes from 1/16 to ½ in. diameter can be accommodated in the Ball-O-Matic universal work holding fixture. Subject of illustrated Brochure BZQ-11, it can be used on arbor or drill press, vertical broach, or other equipment with a vertical ram. Technical data on the process are included. 16 pages. Industrial Tectonics, Inc., 3686 Jackson Rd., Ann Arbor, Mich. H

Circle 619 on Page 19

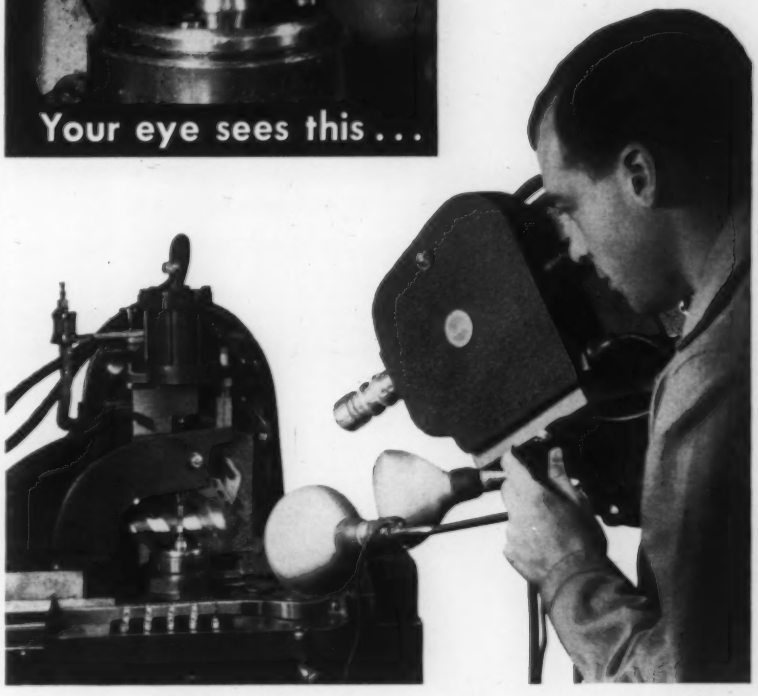
ASME Code

Design index to the ASME unfired pressure vessel code, offered on a durable file-size card, makes available important data that are widely scattered throughout the code. Four indexes cover construction details, radiography, stress-relieving, and ASME and TEMA heat exchanger references. 4 pages. Downingtown Iron Works, Inc., Downingtown, Pa. E

Circle 620 on Page 19

Proportioning Pumps

Quantities ranging from 3 to 7880 milliliters per hour of corrosive or costly chemicals are metered accurately by the Industrial miniPump described in Bulletin 1257. Features of this pump which adapt it for use in laboratory, pilot plant, or other service requiring precision chemical feeding are explained. 2 pages. Milton



. . . but what's *really* happening?

You're looking at a gear shaper in action. To your eye it's only a blur. The way to *study* this event—and other mechanical action too fast for the eye to see—is with high speed movies.

With a Kodak High Speed Camera you shoot at speeds of 1000 to 3200 frames per second—the range used for most work in machine tool analysis. When you project the completed film at a normal 16 frames per second, action is slowed as much as 200 times. Once you see what's actually happening, solutions are usually easy to find.

You can do more things with high speed movies because of new Kodak films available. Some of them are Cine-Kodak Tri-X (Reversal or Negative), Cine-Kodak High Speed Infrared, and Kodachrome.

To see how others have solved problems with high speed movies, send for the booklet "High Speed Motion Pictures at the Service of the Engineer."

A FEW TYPICAL APPLICATIONS . . . Metal cutting, forming and grinding . . . Impact and tension tests . . . Mixing actions . . . Vibration . . . Mechanical power transmission

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

the Kodak

***HIGH SPEED* Camera**

Kodak

BEAVER BALL SCREWS

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficient in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments, aircraft, machine tools, massive wind tunnel jacks, etc. For horizontal and vertical actions, indexing, inching and traversing. Consultation and engineering service available. Write for literature.

• EXTREME ACCURATE POSITIONING • NO BACKLASH • RAPID START • ANY DIAMETER OR TRAVEL •

Beaver Precision Products INC.
CLAWSON, MICH.

Circle 479 on Page 19

Helpful Literature

Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa. E

Circle 621 on Page 19

Motor Controls

"Quick selector" tables in illustrated Catalog 5800 make electric motor control selection easy. They give horsepower, motor speed, heater size, and heater ampere ratings, plus enclosure choices and prices. Data are included on magnetic starters and contactors, drum controllers, pressure switches, and push buttons. 56 pages. Furnas Electric Co., 1045 McKee St., Batavia, Ill. I

Circle 622 on Page 19

DC Contactors & Relays

Design and technical data on a complete line of direct current contactors and relays are contained in Catalog GEA-6621. Types covered include general purpose, mill type, and time delay contactors, and instantaneous overload, thermal overload, field loss, field accelerating and decelerating, and high drop-out relays. 32 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 623 on Page 19

Automatic Lubricator

Details of a new solenoid-operated lubricator which distributes lubricating oil from a self-contained reservoir or from reservoirs in the machine itself to up to 20 bearing points are presented in Bulletin TR-57-E. 2 pages. Bijur Lubricating Co., 151 W. Passaic St., Rochelle Park, N. J. D

Circle 624 on Page 19

Plastic Pipe Clamp

Actuated by a deep-slotted or collared screw which engages with slots in the band, Suretite stainless steel or cadmium plated clamps are designed to fasten plastic pipe to fittings. Details are given in Form PP-1057. 2 pages. Wittek Mfg. Co., 4305-37 W. 24th Place, Chicago 23, Ill. J

Circle 625 on Page 19

Ceramic Parts

Described in "Manufacturer's Catalog" are high alumina, Steatite, Cordierite, and Zirconite ceramics. Information is given on standard extrusions, ceramic properties and specifications, and metallized components. 16 pages. Globe-Union Inc., Centralab Div., 900 E. Keefe Ave., Milwaukee 1, Wis. K

Circle 626 on Page 19

Brass Products

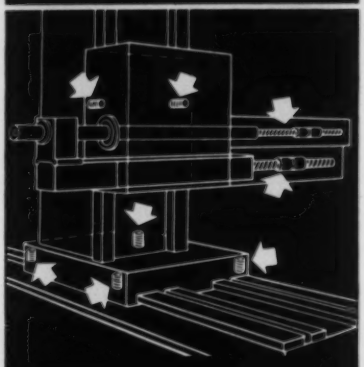
Chemical, physical, and mechanical properties and specifications of Titan brass products are detailed in booklet entitled "Titan Alloys." Technical data are presented in convenient form on brass rod, wire, welding rod, hot pressed forgings, and pressure diecastings. 16 pages. Titan Metal Mfg. Co., Bellefonte, Pa. G

Circle 627 on Page 19

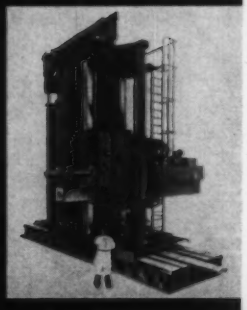
Shaft-Mounted Positioners

Shaftrol and Valvetrol shaft-mounted positioning gearmotors for valves, drives, pumps, and other applications are described in Bulletin J-101. Speci-

Versatility!



THE WORLD'S LARGEST FLOOR TYPE HORIZONTAL BORING - DRILLING - MILLING MACHINE USES 6 BEAVER BALL SCREWS FOR POSITION CLAMPING AND 2 FOR SPINDLE FEED



The same accurate positioning, rigidity and freedom from backlash essential in this huge Giddings and Lewis Model 1210-FUAR with 10" spindle is available to you for improving the efficiency of your equipment. Consultation and engineering service. Write for literature.

Beaver Precision Products INC.
CLAWSON, MICH.

Circle 479 on Page 19

Helpful Literature

fications on a new digital control system for machine tool positioning and for process control are presented also. 8 pages. Jordan Co., 3235 W. Hampton Ave., Milwaukee 9, Wis. K

Circle 628 on Page 19

Solenoids

Direct current torque charts and other performance data on 156 stock models of five rotary solenoids are contained in Bulletin 1057-S. Also detained is a full-wave rectifier. 12 pages. G. H. Leland, Inc., 123 Webster St., Dayton 2, Ohio. C

Circle 629 on Page 19

Electric Brakes

Comprehensive "Technical Report" on Power-Safe electric brakes contains complete design and engineering information, including descriptions and operation, technical data, and details of controls. Detail drawings, performance charts, and suggested layouts are included. 86 pages. Warner Electric Brake & Clutch Co., Beloit, Wis. K

Circle 630 on Page 19

Centrifugal Pumps

Performance and application information on 21 direct and belt-driven self-priming centrifugal pumps with capacities up to 1600 gpm are given in Data Sheet 334. 2 pages. Barnes Mfg. Co., Mansfield, Ohio. G

Circle 631 on Page 19

Ball Bearings

Functional precision Type BR ball bearings with bore diameters from 3/16 to 1 in. are described in illustrated brochure. Tables give dimensions. 4 pages. Schatz Mfg. Co., Poughkeepsie, N. Y. D

Circle 632 on Page 19

Electrical Insulations

"Micanite Mica Splitting Products" and "Lamicoid Rigid Laminate Plastics" are titles of two comprehensive guidebooks on these materials. Properties, application information, available sizes and forms, and other design data are included. 20 pages each. Mica Insulator Co., Schenectady 1, N. Y. C

Circle 633 on Page 19

Energy Transducer

The solion is an electronic device that may replace the transducer at frequencies below 100 cps. Operating principle, general characteristics, applications, and proposed circuit components are dealed in bulletin entitled "Solions for Industry." 4 pages. National Carbon Co., Electronics New Products Dept., Box 6056, Cleveland 1, Ohio. C

Circle 634 on Page 19

Pump Castings

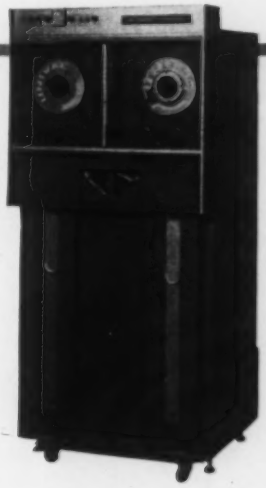
"Meehanite Pump Castings" is title of illustrated Bulletin 36. Shown are pump castings and the various types of pumps that use them. Tables list property evaluations made from tests covering wear, resistance to acid corrosion, impact, and erosion. 20 pages. Request on company letterhead to Meehanite Metal Corp., 714 North Ave., New Rochelle, N. Y. D

in this data processing equipment . . .

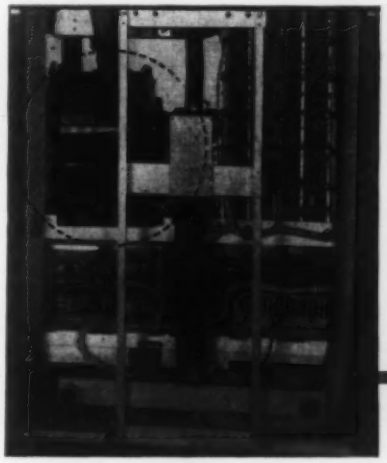
a SPENCER Vacuum Unit

Solved TWO design problems!

Uniservo for Remington Rand Univac® II system.



How to maintain proper tension on the metal or plastic tape was one problem. How to cool the tubes was another.



A ⅓ H.P. SPENCER vacuum unit solved *both* design problems. Intake side is utilized to keep the tape taut . . . exhaust is used to ventilate the cabinet and keep tubes cool.

Perhaps vacuum can help solve *your* design problem. Why not check with SPENCER, manufacturers of a complete line of vacuum and blower units . . . for standard or special requirements.

Two Catalogs to Aid the Designer

"132 UNUSUAL USES OF SPENCER VACUUM" Bulletin 144 illustrates and describes how Spencer Vacuum is used in industries from A to Z.

"TURBO DATA BOOK" Supplies application data on Spencer Blowers. Request Bulletin 107-C.

STANDARD CAPACITIES of Spencer Vacuum Producers

2 through 400 H.P.

Up to 12" Mercury Vacuum

Volumes up to 17,000 C.F.M.

The SPENCER TURBINE COMPANY

HARTFORD 6, CONNECTICUT

Circle 480 on Page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Clinch Nut

is designed with integral metal cap

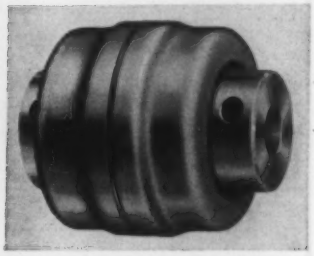
LHCFKM miniature clinch-type self-locking nut with integral metal cap was developed for use inside a miniature transformer. For other applications when potting is not involved, cap can be used to protect closely packed, delicate wiring and components from bolt-end damage. Fastener is mounted by expanding short, knurled shank in installation hole. It becomes a fixed fastener, suited for applications where space will not permit normal wrenching or where a blind nut is required. Nut is available in 4-40, 6-32, and 8-32 threads, with shank length of 0.040 in. for use in material 0.030 to 0.050 in. thick. The 8-32 is also designed with shank of 0.060 in. for use in material thicker than 0.050 in. Nut meets torque requirements of AN - N - 10 and/or MIL - N - 25027 (ASG). Nut and cap are of heat and corrosion-resistant steel. **Elastic Stop Nut Corp. of America,** 2330 Vauxhall Rd., Union, N. J. C

Circle 635 on Page 19

Couplings

transmit torques to 150 oz-in.

Metro-Flex couplings are suitable for servomechanisms, computers, tachometer takeoffs, oscillographs, or other applications where two small shafts need to be coupled with precision. They handle angular misalignment of driving and driven shafts to 5 deg, parallel offset to 0.010 in., and axial end play to 0.090 in. Couplings provide constant rotational velocity, transmit torques to 150 oz-in., and permit speeds to 10,000 rpm. They minimize backlash, provide high torsional rigidity, and operate over a temperature range of −10 to 250 F. Couplings are available with hubs bored to receive 3/16, ¼, 5/16, or ⅜-in. shafts or combinations of these sizes. Overall diameter of coupling is 1.078 in. **Metron Instrument Co.,** 432 Lincoln St., Denver 3, Colo. K

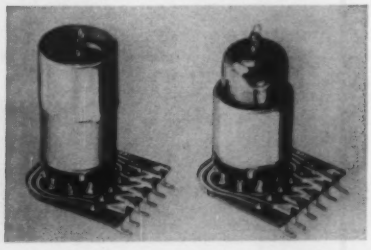


Circle 636 on Page 19

Right-Angle Sockets

incorporate new tube shield

Right-angle shielded sockets incorporate a self-contained and telescopic tube shield with bayonet locking feature to maintain it in raised position (left). Upper half is disengaged with a slight twist and lowered (right) so that tube can be removed for servicing or replacement. Base material of sockets is 1/16 in. XXP phenolic with 0.00135 in. copper capable of carrying 6½ amp. Sockets can be furnished in quantities using a base laminate of glass epoxy material. Both grades of material can be furnished to 3/32 in. thick. **Cleveland Metal Specialties Co.,** 1783 E. 21st St., Cleveland 14, Ohio. G

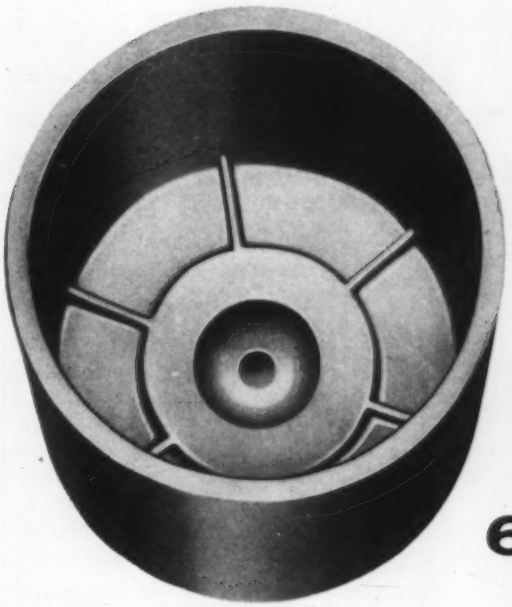


Circle 637 on Page 19

Servo Motor Gearhead

is two-speed unit

X-544 two-speed precision servo motor gearhead changes ratios internally when dc voltage is applied to, or removed from, an actuating solenoid. Ratios in Size 14 unit (shown) are 1800:1 de-energized and 36,000:1 energized. Similar two-speed units are available in all ratios or combinations of ratios required. Gearheads are furnished with housings to mount to servo motors. Designed for integration with Sizes 11, 14, or 18 motors, unit requires 0.008 oz-in. starting torque, and operates 12 oz-in. load torque. Operating at the higher ratio, assembly has maximum backlash of 1 deg with 5 oz-in. reversing load, and it introduces up to 5 min of position change when it shifts speed. Gearhead operates in ambient temperature range of −40 to 125 C. Primary application is in positioning



6 INTERNAL SPOKES WITHOUT MACHINING!

Another typical design application of Hunter Douglas Aluminum Cold Forgings.

Those radial spokes on the inside bottom face of this instrument case were held to ±.005" thickness and to .5° for location. Yet the complete case was instantly impact extruded from a starting slug of 6011 aluminum alloy! Except for simple secondary machining operations—trimming to length and drilling—the part is ready for final assembly, as forged.

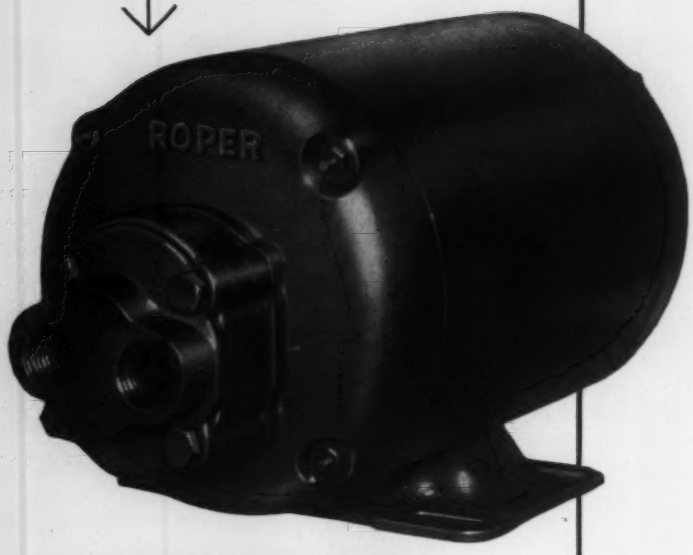
Hunter Douglas Aluminum Cold Forgings assure *precision tolerances, no draft, minimum machining, high strength, no porosity, excellent surface finishes.* These rewarding advantages can also be yours when you design with Hunter Douglas cold forging in mind.

Want more information about this process? Ask for free booklet, "The Story of Aluminum Cold Forging."

These industrial parts, many with intricate shapes, are typical of thousands produced by Hunter Douglas Aluminum Division of Bridgeport Brass.

Hunter Douglas Aluminum Division of Bridgeport Brass Company • Department MD2, 3016 Kansas Avenue, Riverside, California

NEW



ROPER

T-SERIES PUMP UNIT

Compact, Integral Construction

.6 to 6.8 GPM — Pressures to 400 PSI

for Hydraulic, Pressure Feed, or Transfer Work

Space-savers for those stationary or mobile units where dependable pumping is a must. That's the new T Series by Roper . . . the compact pump unit that is approximately the same size as a standard motor of HP required for driving. The pump serves as the end bell of the motor . . . design eliminates a coupling, thus conserving valuable space. Look into it now — it can well solve some of your pumping problems.

- ✓ **PUMP HOUSING** — High density cast alloy iron. Single piece back plate serves as end bell of motor.
- ✓ **PORTS** — ½" NPT in faceplate for convenient connections.
- ✓ **GEARS** — Fatigue-proof steel spur gears run in axial hydraulic balance.
- ✓ **BEARING** — Heavy duty bronze assures accurate alignment of elements.
- ✓ **SEAL** — Lip type, with pressure relief system built-in to maintain zero pressure in seal chamber.
- ✓ **MOTORS** — Single phase, 60 cycle (standard) . . . open drip-proof or totally-enclosed. ¼ to 1 HP — single or dual voltage depending on size or need.

Send for Bulletin 31 Today

242 BLACKHAWK PARK AVE.

ROCKFORD, ILLINOIS

ROPER

HYDRAULICS, INC.

New Parts

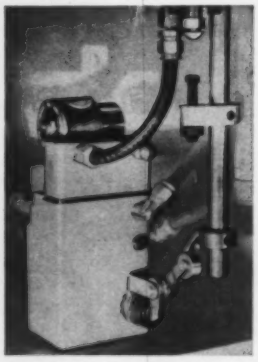
computing mechanisms which require fast approaches, but slower zeroing or synchronizing action. **Bowmar Instrument Corp.**, 8007 Bluffton Rd., Ft. Wayne, Ind. J

Circle 638 on Page 19

Four-Way Valve

actuates pneumatic equipment

Control-Pac four-way slide valve can be used to reciprocate double-acting cylinders through either long or short stroke. It can control more than one mechanism, and controls parts escapement and positioning action in high-output assembly operations. Complete unit includes a pilot-operated slide



valve, remote-return control valve, electrical junction box with provision for air silencer, and either electric or pneumatic initiation. It is designed for mounting on or near a power head. Enclosed in a dust and splashproof cover, unit can be installed in a wet or dirty environment. Piston and slide valve are nylon. Cycle is initiated manually or by a 110-v electrical pulse. **Dixon Automatic Tool Inc.**, 2300 23rd Ave., Rockford, Ill. K

Circle 639 on Page 19

Printed-Circuit Connectors

have nylon polarizing keys

Printed circuit-board receptacles are of one-piece body construction. and are available in Type GR and MFE mineral-filled phenolic, MDG diallyl phthalate, or CFG general-purpose phenolic. New contact design prevents board-to-contact damage. Contact material is beryllium

BLOOD BROTHERS SERVES INDUSTRY

WITH UNIVERSAL JOINTS AND ASSEMBLIES FOR ALMOST ANY PRODUCT APPLICATION

SIZES AND TYPES FOR HEAVY-DUTY AUTOMOTIVE, CONSTRUCTION AND ROAD BUILDING MACHINES, FARM IMPLEMENTS, TRACTORS AND INDUSTRIAL MACHINERY.

SAVE ENGINEERING TIME!

Here at Blood Brothers you can select from a wide, wide range of universal joints and complete drive assemblies. Torque capacities range from 350 to 500,000 inch lbs. — lengths from very close-coupled industrial joints to assemblies 120" overall.

You can be confident they are produced in a modern, centrally located plant, tooled for precision manufacturing. And you can rely on their high reputation for dependability.

When you specify Blood Brothers, you can save valuable engineering time by stating your problem to our service-minded engineers. They're cooperative, friendly and long-experienced. Just write or call.

WRITE FOR BULLETIN 557

and for your convenience in specifying, request our free Blank Form "Specification Sheets".

BLOOD BROTHERS MACHINE DIVISION

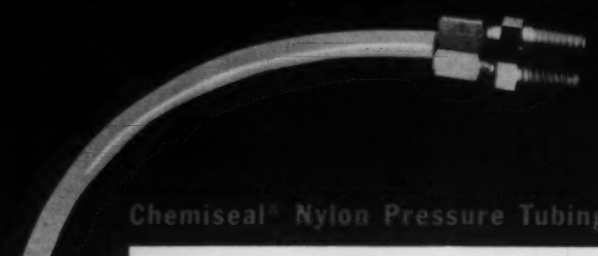
ROCKWELL SPRING AND AXLE COMPANY

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

Copyright 1957, Blood Brothers Machine Div.

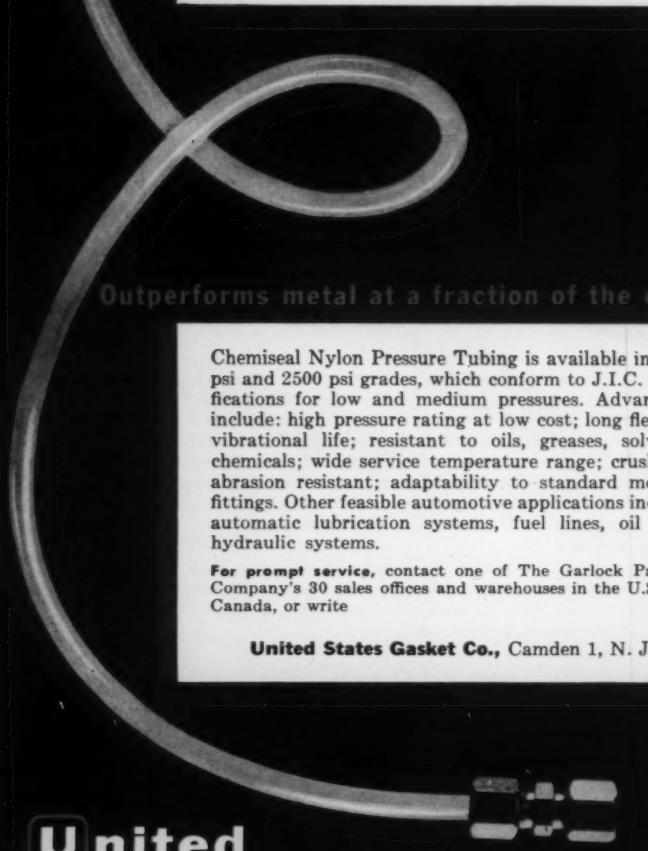
Original Equipment on the New Air Suspension



Chemiseal® Nylon Pressure Tubing

. . . has provided automotive engineers with a new "tool" for accomplishing a great advance in motorcar riding comfort.

This light, strong, flexible tubing—many feet of it per car, which connects the various components of the pneumatic system—meets stringent performance requirements at a fraction of the cost of metal tubing with required flexible couplings and intermediate fittings. And it is easier to install—saves assembly time.



Outperforms metal at a fraction of the cost

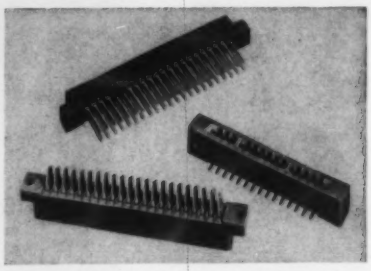
Chemiseal Nylon Pressure Tubing is available in 1000 psi and 2500 psi grades, which conform to J.I.C. specifications for low and medium pressures. Advantages include: high pressure rating at low cost; long flex and vibrational life; resistant to oils, greases, solvents, chemicals; wide service temperature range; crush and abrasion resistant; adaptability to standard metallic fittings. Other feasible automotive applications include: automatic lubrication systems, fuel lines, oil lines, hydraulic systems.

For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses in the U.S. and Canada, or write

United States Gasket Co., Camden 1, N. J.

United States Gasket Plastics Division of GARLOCK

New Parts



copper, and standard plating is gold over silver. Nylon polarizing keys permit quick interchangeable polarizations. Standard terminations are solder eye, taper tab, solder dip, and wire wrap, for either single or double-sided board circuits. Minimum creep is 3/32 in., and working voltages are 550 ac and 770 v dc. **H. H.Buggie Inc.,** Box 817, Toledo 1, Ohio. G

Circle 640 on Page 19

Blind Rivet

steel unit provides high-strength fastening

Daisy steel blind rivet provides high-strength fastening for all types of light sheet-metal applications, truck-trailer applications, heating and ventilating duct work, and other fabricated metal products. Swaged positive mechanical lock insures pin retention. Fastener is available in 5/8 and 7/8-in. split sleeve length. Each size has a 7/16-in. diam washer-type collar. Grip

range for the shorter fastener is 0.032 to 0.250 in.; longer unit has a grip range of 0.032 to 0.375 in. **Huck Mfg. Co.,** 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 641 on Page 19

Prefinished Metal

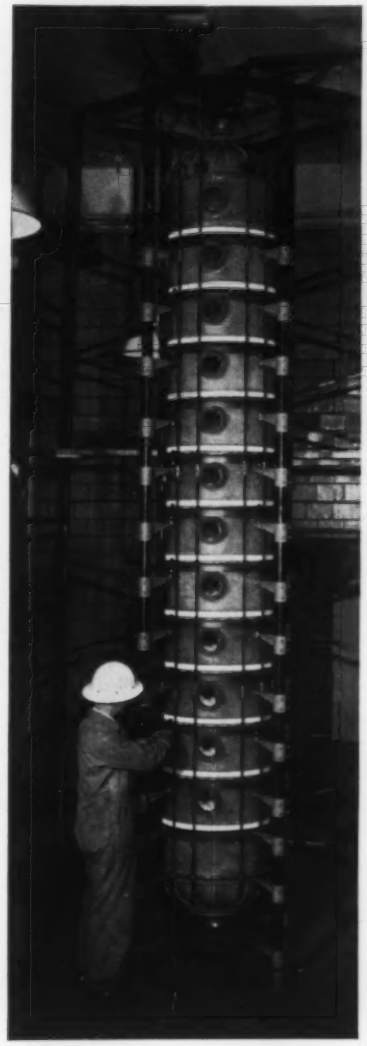
has protective coating

Prefinished metals are now available with Mar-Not protective coating, permitting use in severe fabricating and handling conditions

THIS IS GLASS

a bulletin of practical new ideas *from Corning*

A tall tale of bubbles without troubles . . . plus a few other ideas



What you're looking at is an *all-glass* bubble cap distillation column, the *largest* ever built using glass for *all* the main components.

The people who came to us for this outsized (16′ high, 23½″ diameter, 2,000 pounds) bit of plumbing make metallic silicon.

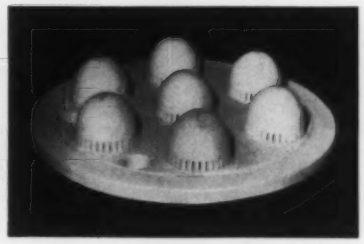
What's uppermost in their mind is product *purity*. Which means process equipment must *not add to nor take from* what's put through it.

Therefore, glass (what else?)—with all the parts custom-fashioned by us (who else?).

The big cylindrical sections (including 4-inch conical pipe flanges) are of No. 7740 glass that stands up to just about every kind of chemical attack.

Between each section you'll find bubble cap plates—12 in all, *twice* the usual number for added purity.

Made from a high-silica, heat-resistant VYCOR brand glass, these plates weigh 65 pounds apiece. They look like this.



To make them, we use the Multiform process, a method in which powdered glass is slip cast, then *fused* to make complex shapes possible.

Don't stop yet . . .

OK, *you* don't make metallic silicon. Maybe you have nothing to do with chemical processing. Still there's probably something you want that Corning can help with.

Like? Selective transmission of infrared or ultraviolet rays. There are various types of VYCOR glassware to handle such tasks.

Shoulder beads, headers, transistor beads, diode cases? Multiform gives you these with excellent *dimensional accuracy*.

Or maybe capacitors, resistors, attenuator plates and such. You get facts on these in a folder sized to fit the inside pocket of your suit coat.

The VYCOR *line* is explained in Bulletin B-91. Multiform data sheet and/or samples on request. Also for your files: PE-60, "PYREX brand industrial radiant heater catalog," telling all about longwave, *area*-source heating.

And "This Is Glass," a sprightly review of what glass is doing, and can do for you. Use the coupon.

Precision glass tubing tackles tough transformer task

Follow a coast-to-coast telephone cable and you'll find relay stations every three miles or so.

At these relay points are two tiny transformers. And inside the transformers of one manufacturer you'll find coils formed around short lengths of VYCOR brand *glass* tubing.

This tubing we make from one of our 96% silica glasses—a very *high-quality* stuff, notable for its lack of bubbles, striae or cords, the kind of things that *might* hamper machining operations.

VYCOR tubing was picked for a number of reasons, *all* of them adding up to the fact that these transformers have to *last 30 years* without replacement, since some are installed in remote mountains, and others buried in river beds.

First off, VYCOR tubing won't cause any trouble when temperature changes occur. It has excellent *dimensional stability*, having an expansion coefficient of 8.0 x 10^{-7} per °C.

VYCOR tubing also offers high chemical stability. Even though metallic coatings are applied to the glass, there's *no* reaction or corrosion.

Finally the tubing can be *finished* to high precision on both inside and outside diameters. And where needed, threads or other shapes can be cut in the glass.

Precision VYCOR brand tubing is *not* much *to look at*, but it *is* something to measure. Inside diameter is held to ±.001″, with wall thickness controlled to +.015″ and a minus *nothing*.

Take a close look and you can see the keyway slot cut into the tubing. It's held to ±.003 in width and ±.002″ in depth.

You can get precision VYCOR brand tubing with ID's from ¼″ to 3 inches, in lengths up to 36 inches. If you can use some, or want more details, contact Railroad and Industrial Sales at the address shown.

Corning means research in Glass

CORNING GLASS WORKS, 52-2 Crystal Street, Corning, New York

Please send me the following material: ☐ Bulletin B-91; ☐ "This Is Glass"; ☐ PE-60

Name ..... Title .....

Company .....

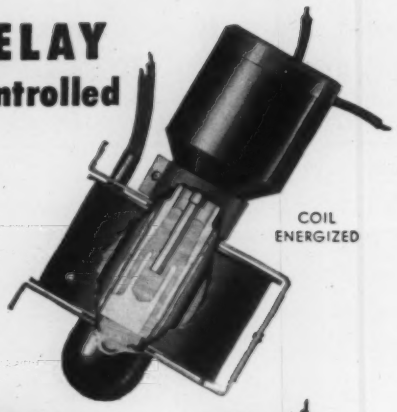
Street .....

City ..... Zone ..... State .....

Circle 485 on page 19

The **TIMER RELAY**
that handles all controlled timing problems . . .

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.



Durakool
STEEL MERCURY TIMERS

★ No false contacts
★ Non sticking
★ Practically "fail safe"
★ Low cost timer

See telephone directory for local distributor, or write.

DURAKOOL, INC.
ELKHART, INDIANA, U. S. A.
700 WESTON RD., TORONTO 9, CANADA

Circle 486 on page 19

Give 'em another round . . . !

John Paul Jones poured round after round of shot into enemy vessels, much the same as Universal pours out round *precision* balls for a variety of products in industrial applications. Whether metallic or non-metallic material, the classic Universal *Precision* Balls are perfect in every respect, with tolerances as fine as 0.000005 of an inch.

If it's a perfect round, it's a Universal Precision Ball.

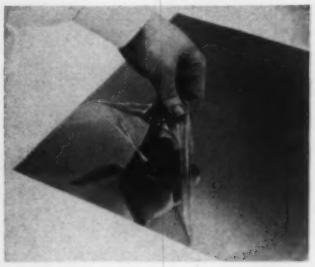
UNIVERSAL QUALITY CONTROL—FOR ALL AROUND PERFECTION

Universal Ball co.
WILLOW GROVE, MONTGOMERY CO., PA.

Circle 487 on page 19

New Parts

without harm to plated finish. Two types of protective coating are available. Type M is a pressure-sensitive paper adhered to the metal by a special adhesive. Type C is a stripping-type plastic film

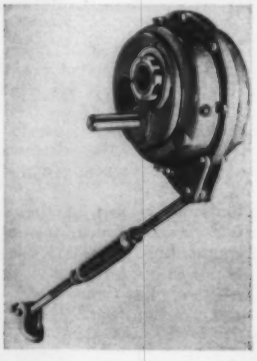


which stretches as the metal is formed. When finished, Type M can be peeled off, and Type C can be peeled or blown off with compressed air. Prefinished metal requires no cleaning, plating, or polishing. **American Nickeloid Co.**, 14 Second St., Peru, Ill. I

Circle 642 on Page 19

Gear Reducer
is shaft mounted

Shaft-mounted gear reducer provides a compact power transmission unit for many industrial applications. It makes possible infinite speed ratios through the use of adjustable-speed pulleys or by changing sheaves, sprockets, or prime mover speed. Single and double-reduction types are available in 18 models. Single-reduction types afford 4.5:1 speed ratio (nominal), and double-reduction types, 14.7:1 speed ratio. Power ratings range from fractional to 120, output speeds from 8 to 425 rpm. Reducer is easily installed direct to driven shaft and



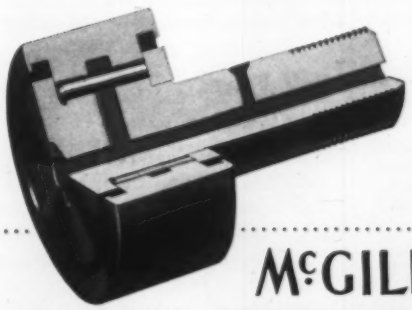
only McGILL® sealed *CAMROL*® cam followers give you . . .

effective sealing

prelubrication

high radial and shock capacity

in a full range of sizes



Effective sealing of the CAMROL cam follower against moisture, dirt, chips, etc. guarantees longer service life . . . reduces maintenance. This sealed construction retains lubricant and eliminates need for frequent relubrication, so often undesirable in cam action, guide support and track roller applications.

Special seals are built in at stud and flange ends. A black oxide finish on all exposed surfaces offers outside corrosion resistance. The channeled reservoir above the rollers in the outer raceway bore helps store reserve lubricant, sufficient in most cases for lifetime service. Relubrication is possible through convenient oil holes. The new SCF sealed CAMROL cam followers interchange with proven standard CAMROL cam followers. Standard stock with roll diameters up to 4″ are available for both stud and shaft mounting.

For maximum bearing life where contamination is a problem, specify sealed CAMROL cam followers. Ask your McGill representative or our engineering department for recommendations.

Write for Catalog No. 52-A

McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Ⓑ NYLOK®

FASTENS, SEALS, and LOCKS IN ONE FOOLPROOF OPERATION

WITHOUT SEALANTS

Ⓑ NYLOK fasteners are sure protection against gasoline, oil, air, and alcohol leaks. Stay locked in ANY depth...need not be fully seated...won't vibrate loose.

Permanent insert of tough, resilient nylon is readily adapted to any Ⓑ threaded fastener. Won't shrink, dry, age, or turn brittle. Unaffected by temperatures to 250°F...cannot damage threads or seating surfaces.

Ⓑ NYLOK fasteners can be reused time after time. Nylon insert regains original shape after using...retains original ability to adapt, lock, and seal to any thread.

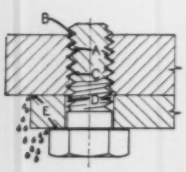
ELIMINATES

- costly locking devices
- double inventory
- lost time in application
- gummed-up threads that prevent reuse
- premature drying of fastener sealants

ASSURES

- instant sealing
- positive locking
- fast assembly... power driving
- smooth torque
- easy hopper feed

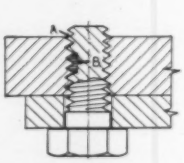
HOW NYLOK WORKS



STANDARD BOLT

← As bolt tightens, metal-to-metal union of LOAD-BEARING faces is made at (A). But, fluid entering at (B) flows downward on NON-LOAD-BEARING faces, leaking out at (D) and (E).

Lateral thrust of NYLOK pellet (B) → presses both LOAD-BEARING and NON-LOAD-BEARING faces tightly together. Fluid entering at (A) is stopped from further flow by NYLOK insert (B).



NYLOK BOLT

WRITE for NEW Special Fastener brochure...call Ⓑ for quotes.

•"THE NYLOK CORPORATION"

BUFFALO BOLT CO.

Division of Buffalo-Eclipse Corporation

NORTH TONAWANDA, N. Y.

• 3 convenient service centers

WESTERN OFFICE	EASTERN OFFICE	CENTRAL OFFICE
Chicago	New York City	North Tonawanda
HArrison 7-2179	REctor 2-1888	JAckson 2480 (Buffalo)

SELF-LOCKING SELF-SEALING Ⓑ NYLOK® FASTENERS

Circle 489 on page 19

New Parts

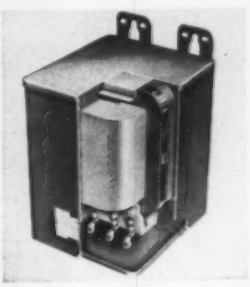
can be mounted vertically or at any angle. Hollow-shaft bores range from 1-7/16 to 5-15/16 in. **Lovejoy Flexible Coupling Co.**, 4882 W. Lake St., Chicago 44, Ill. J

Circle 643 on Page 19

Dry-Type Transformer

has core and coils sealed in resin

Type EP dry-type specialty transformer is suited for application to electrical machinery, panelboards, and general commercial installations. Core and coils are completely encapsulated in resin with filler, permitting installation in hazardous areas. Sound levels average 5 db below NEMA standards. Excellent heat transfer properties of resin and filler make possible units averaging 55 per cent smaller and



14 per cent lighter than previous models. Transformer is available in ratings from ¼ to 10 kva, 600 v and below, and can be mounted in any position on wall, floor, or ceiling. Ratings 3 to 10 kva are suitable for outdoor use. Large-capacity wiring compartment is available, and units rated from 3 to 10 kva have rigid, one-piece molded terminal board. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa. F

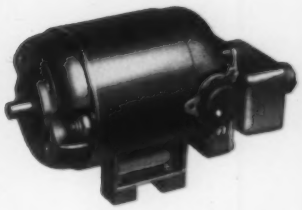
Circle 644 on Page 19

Ball Valves

in ½ to 2-in. sizes

Double-Seal flanged ball valves provide full pipeline flow, no leakage, and minimum maintenance. They are available in ½ to 2-in. sizes. Features include positive shut-off, low torque over complete pressure range from vacuum to full rated pressure, high flow capacity with

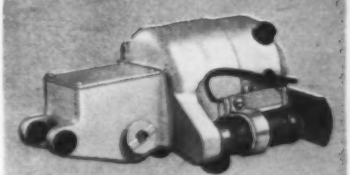
PASSES TESTS WITH FLYING COLORS



Aircraft de-icing pump motor.

Impact concrete drill motor.

Explosion-proof vacuum unit.



Gear motor for slow-speed drive.

If you are interested in any of the above motors write and we shall be glad to send full information.

. . . equal dependability for your product

One of the recent Lamb Electric developments is a motor to drive submerged pumps on military aircraft—for transfer of fuel from reserve to engine tanks.

For such an important application, motor reliability far beyond that normally called for was needed. To insure this degree of reliability in its actual operation of driving the submerged pump, test requirements for the motor were exceptionally rigorous.

As the result of advanced engineering and design, greatly increased brush life, and ability to operate at extremely high temperatures and withstand severe shock tests, the motor passed gruelling tests with flying colors.

The skill and experience exemplified here is available to your company to provide dependable power for *your* new or redesigned products.

THE LAMB ELECTRIC COMPANY • KENT, OHIO

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

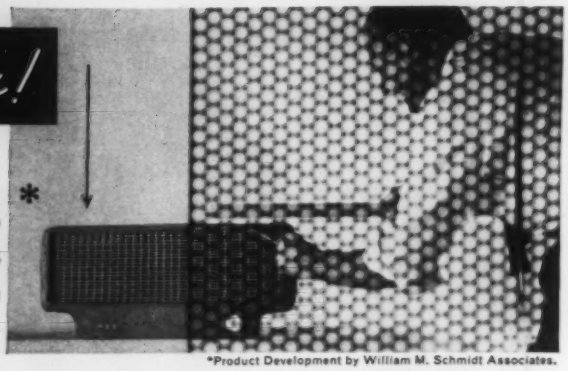
Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Circle 490 on page 19

Idea!

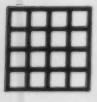
mock-up projects design



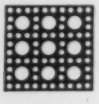
*Product Development by William M. Schmidt Associates.

with H & K perforated metals

A few of the thousands of H & K patterns are illustrated in reduced size



Send today to nearest H & K office for General Catalog



Here is an H & K perforated metal grille utilized in a mock-up of a record player. This greatly helps the Industrial Designer project his concepts as H & K perforated metal is now in its proper element for consideration of use and selection of pattern.

By referring to the H & K General Catalog, the designer can select one or more patterns for his project.

H & K perforated metals provide the Industrial Designer, and other men of ideas, a medium of unlimited opportunities for designing better and more attractive products.

THE Harrington & King PERFORATING CO. INC.

Chicago Office and Warehouse
5670 Fillmore Street
Chicago 44, Illinois

New York Office and Warehouse
114 Liberty Street, Dept. MD
New York, New York

Circle 570 on page 19

WRITE FOR COMPLETE NEW ENGINEERING BULLETINS

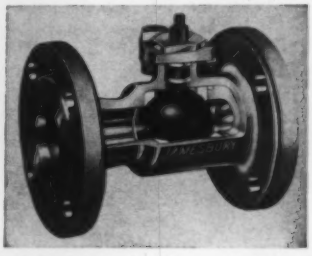
PHILLIPS SUB-MINIATURE RELAYS

IN PERMANENT BINDER: Latest set of Phillips Relay engineering bulletins, including subminiature units, are ready for your reference files now. Easy-to-read, comprehensive, loose-leaf data sheets in durable ring binder. Write for your relay file today.

Phillips Control Corporation, Joliet, Illinois — AN ALLIED PAPER CORPORATION SUBSIDIARY — SALES OFFICES: NEW YORK - PHILADELPHIA - BOSTON - SAN FRANCISCO - DENVER - SANTA MONICA - WASHINGTON - WINSTON SALEM - CLEVELAND - DALLAS - SEATTLE - KANSAS CITY - ST. LOUIS - DETROIT

Circle 491 on page 19

New Parts



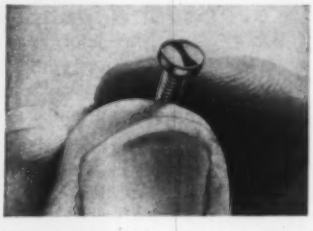
minimum friction loss, and seats and seals which are interchangeable and replaceable. **Jamesbury Corp.**, 45 New St., Worcester, Mass. B

Circle 645 on Page 19

Miniature Screws

for use in electronic components

Miniature Hi-Torque screws, available in sizes as low as No. 2-56, are infinitely reusable. For use in the assembly of electronic systems, they will not burr when difficult driver access angles are encountered. Hi-Torque head assures consistent, positive lock with driver during removal and fastening operations. Screws can be used where low head or flush bolt heights are specified. They are available in ferrous and nonmagnetic metals for use in special electronic devices. **Voi-Shan Mfg. Co.**, 8463 Higuera St., Culver City, Calif. L

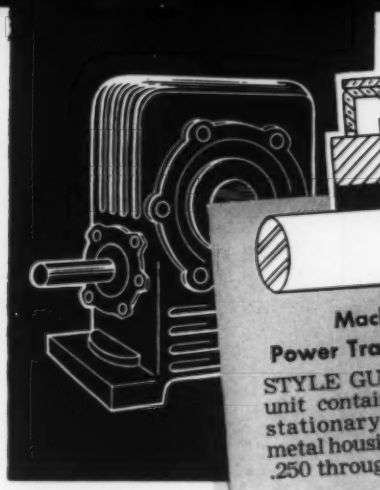


Circle 646 on Page 19

Variable Resistors

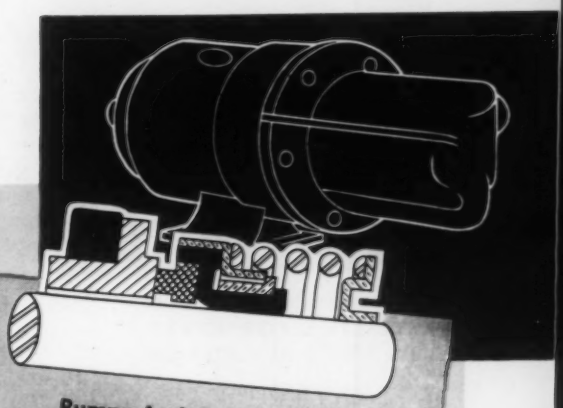
two and three-unit types have plug-in mounting brackets

New two and three-unit side-by-side variable resistors, equipped with plug-in mounting brackets, are available in 12 basic types for television receivers and other electronic assemblies. Each type has 17 shaft lengths. Printed-wiring terminals and snap-in metal



Machine Tools And Power Transmission Equipment

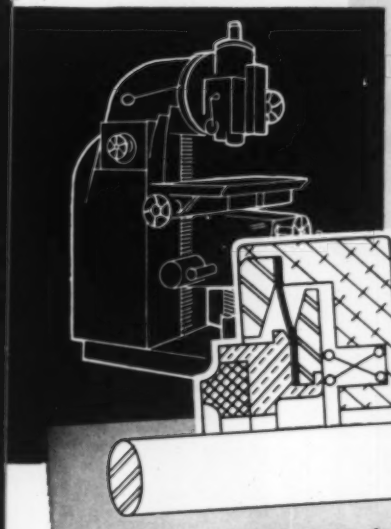
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

A Complete Line

GITS SHAFT SEALS

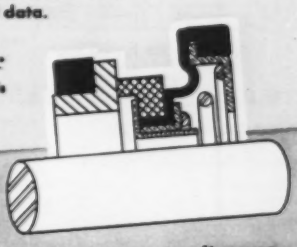
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

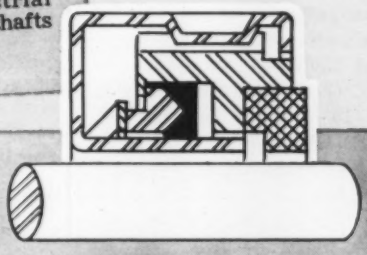
1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



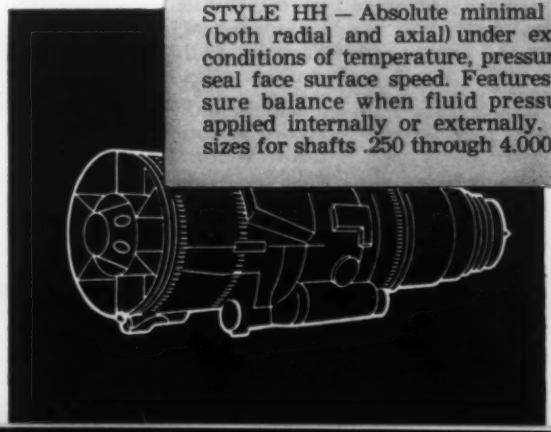
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.

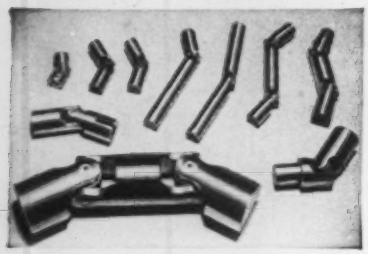


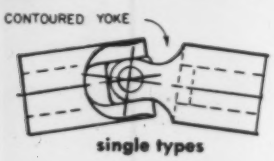
Circle 492 on page 19

Lovejoy

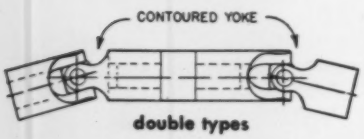
UNIVERSAL JOINTS

INDUSTRY'S MOST COMPLETE LINE FOR EVERY SLOW SPEED APPLICATION





single types



double types

Check these features against your requirements:

Special Contoured Yoke—capable of operating at a maximum angular misalignment of 45° on hand-operated applications.

Static Torque—from 306 to 129,693 in.-lbs. at 12°, depending on size of joint.

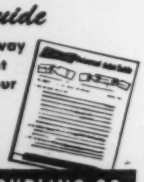
Horsepower Ratings—.54 to 207 at 100 rpm.

Tolerances—pins ground to .0005" ... forks concentric to within .001" ... precision accurate center blocks.

Standard Specifications—hub diameters ½ to 4" ... bores ¼ to 2" ... lengths (single) 2 to 10⅝"; (double) 4 to 21¼". All specifications can be altered or special joints designed to individual requirements.

Get this handy guide

It's the quick and easy way to get the Universal Joint that is just right for your application. Request Bulletin 820.



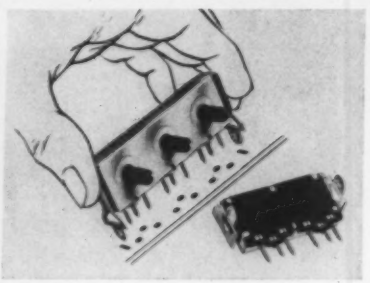
LOVEJOY FLEXIBLE COUPLING CO.

4818 W. Lake St. Chicago 44, Ill.

Circle 493 on page 19

New Parts

mounting brackets provide firm support for multiple-control assemblies. Screwdriver-slotted phenolic shafts are adjustable from both sides. Longer shaft extensions on one side are available in standard lengths from 0.024 to 1.270 in. from mounting surface. Plug-in mounting brackets are



available for chassis or panel mounting, regardless of terminals or shaft styles. **Electronic Components Div., Stackpole Carbon Co.,** St. Marys, Pa. F

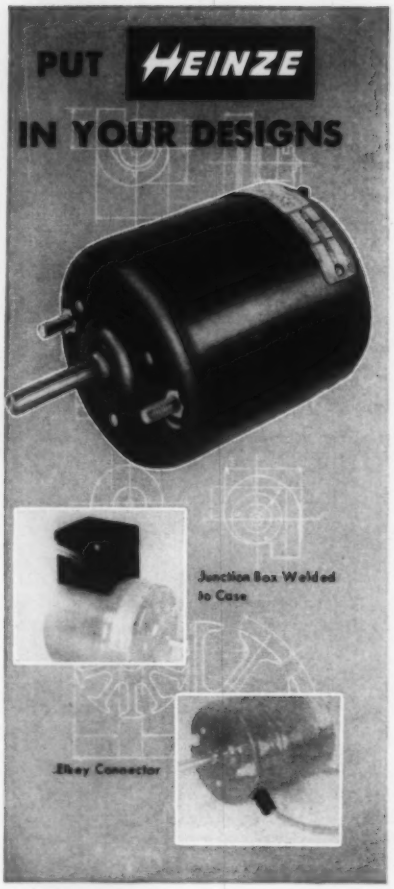
Circle 647 on Page 19

Motor Alternator

develops two output frequencies

MA-3 motor alternator incorporates a conventional hysteresis-type synchronous motor driving a pair of permanent-magnet alternators through appropriate gearing. It is flexible in design for use in special-purpose applications. Unit develops two output frequencies, 90 and 150 cycle, from 400-cycle input. Outputs are matched to within 1/10 of 1 per cent over the temperature range of − 55 to 65 C. Wave-form distortion is less than 2 per cent. Separate outputs can be synchronized so that waves have a definite phase relationship to ± 2 deg of one another.

PUT HEINZE IN YOUR DESIGNS



TYPE D INDUCTION MOTOR

for trouble-free performance

This 2-pole shaded pole induction motor has a free speed of approximately 3400 rpm, with recommended load speeds of 3000 and 3100 rpm. Available for 115 V AC, 60 cycle operation, CW or CCW rotation.

Different voltages or 50 cycle operation available on request. Other variations include ventilated case, junction box welded to case or Elkey connector. Choice of mountings—flat strap bracket, saddle type bracket or resilient plate.

Heinze motors are also designed to your exact specifications. Write Dept. D for free catalog.

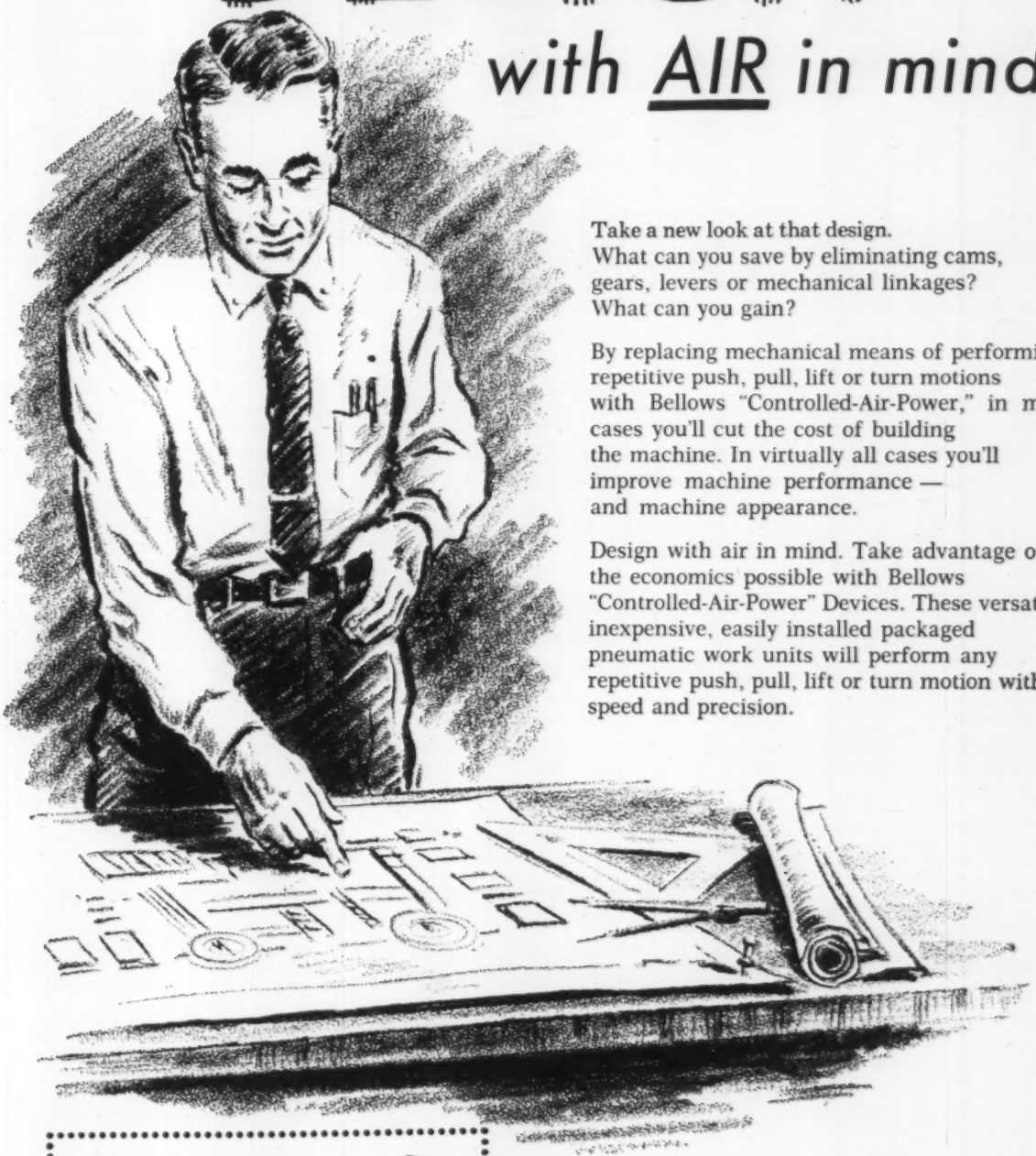
HEINZE ELECTRIC COMPANY

685 Lawrence St., Lowell, Mass.

Circle 494 on Page 19

DESIGN

with AIR in mind



Take a new look at that design.
What can you save by eliminating cams, gears, levers or mechanical linkages?
What can you gain?

By replacing mechanical means of performing repetitive push, pull, lift or turn motions with Bellows "Controlled-Air-Power," in most cases you'll cut the cost of building the machine. In virtually all cases you'll improve machine performance — and machine appearance.

Design with air in mind. Take advantage of the economics possible with Bellows "Controlled-Air-Power" Devices. These versatile, inexpensive, easily installed packaged pneumatic work units will perform any repetitive push, pull, lift or turn motion with speed and precision.

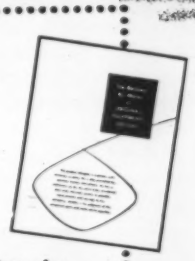
READ THIS STORY—

"The Place of the Bellows Air Motor in Original Equipment Design."

This new 14 page booklet will be of help to any design engineer.

Write Dept. MD258,
The Bellows Co., Akron 9, Ohio

In Canada: Bellows Pneumatic Devices of Canada, Ltd., Toronto, Ontario



The Bellows Co.
AKRON 9, OHIO

893-B

GEAR-GRIP

The most revolutionary Flexible Coupling Design Development in a century!

●

Now available for sub-fractional, fractional and integral H.P.

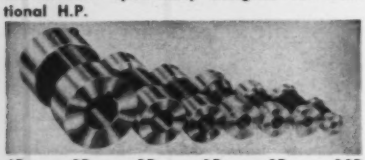
●

Ability of rubber Flex-Element to float between captive end fittings distributing load similar to universal joint action.

- Load Ranges—1/12 H.P. through 30 H.P.
- Shaft Sizes—1/8 through 1-7/8.
- Specified exact length to design requirements per series.
- Prevention of end thrust among many other design advancements.

Dyna-Line . . .

The finest flexible coupling in single unit construction—specifically designed for fractional H.P.

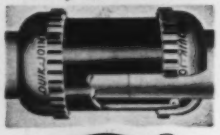


4R 3R 2R 1R 0R 00R

- True Flexibility and Torsional Resilience for quiet, load-plus power transmission without extreme deflection or twist.
- Lengths varied to design specifications in each series.
- Load ranges—1/15 to 1½ H.P.
- Shaft sizes—3/16" to ¾".

Quick-Joint Steel Compression Pipe Fittings

- UL approved for hazardous fluids.
- Guaranteed for 2000 p.s.i.
- Allows 7° angular deflection.
- No threading of pipe required.
- Special Silicone Gasket for Steam applications.



Write for Catalogs and Technical Bulletins.

Guardian PRODUCTS CORP.
COUPLING DIVISION
Dept. M-28
Michigan City, Indiana

Circle 496 on page 19

New Parts

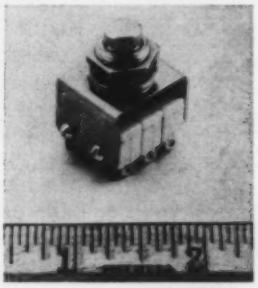
Output voltages and frequencies can be modified to suit specific application requirements. Unit meets military specifications. **Eastern Air Devices Inc.**, 385 Central Ave., Dover, N. H. B

Circle 648 on Page 19

Small Actuator

operates three subminiature switches

Panel-mounted, overtravel plunger-type actuator assembly operates three subminiature precision switches simultaneously. Assembly, including the three switches, measures 1 x 1¼ x ¾ in. Typical use is in portable vibration detection devices. **Acro Div., Robertshaw-Fulton Controls Co.**, 2040 E. Main St., Columbus 16, Ohio. G

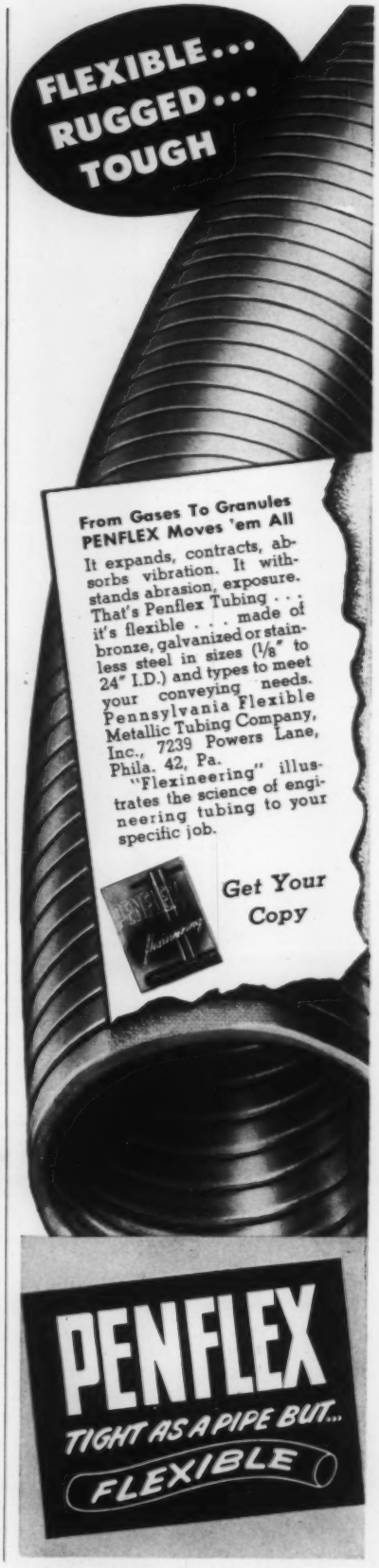


Circle 649 on Page 19

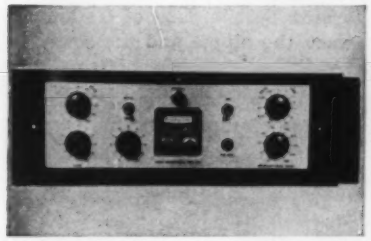
Electric Control Units

have interchangeable output sections

Electr-O-Line, Electr-O-Pulse, and Electr-O-Volt control units incorporate replaceable printed circuits, continuously adjustable proportioning reset and rate action, and silicon diodes for power supply. They are for use in the metals producing and processing industries in conjunction with potentiometers to control furnace temperatures. Units consist of three sections mounted in a die-cast aluminum chassis with adjustments made from front panel. Amplifier and power supply sections are the same for each unit. Control output section differs in each unit, but conversion from one controller to another is accomplished by plug-in of desired output section. Electr-O-Line (shown) operates a pair of relays


FLEXIBLE . . .
RUGGED . . .
TOUGH
From Gases To Granules
PENFLEX Moves 'em All
It expands, contracts, absorbs vibration. It withstands abrasion, exposure. That's Penflex Tubing . . . it's flexible . . . made of bronze, galvanized or stainless steel in sizes (1/8" to 24" I.D.) and types to meet your conveying needs. Pennsylvania Flexible Metallic Tubing Company, Inc., 7239 Powers Lane, Phila. 42, Pa.
"Flexineering" illustrates the science of engineering tubing to your specific job.
Get Your Copy
PENFLEX
TIGHT AS A PIPE BUT...
FLEXIBLE

Circle 497 on page 19



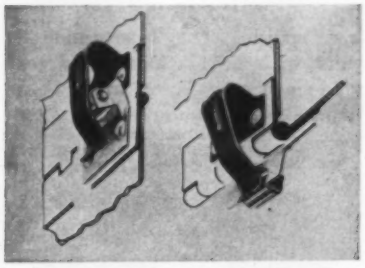
energizing the open or closed winding of a motor or other final actuator. **Brown Instruments Div., Minneapolis-Honeywell Regulator Co.**, Wayne & Windrim Avenues, Philadelphia 44, Pa. E

Circle 650 on Page 19

Door-Retaining Spring

provides easy access through small doors

Small spring-and-cam-type door-retaining spring provides easy access to frequently used doors. Occupying a minimum of interior space, it holds small doors tightly closed or open. Fastener, consisting of a hardened-steel spring acting over a smooth brass roller,



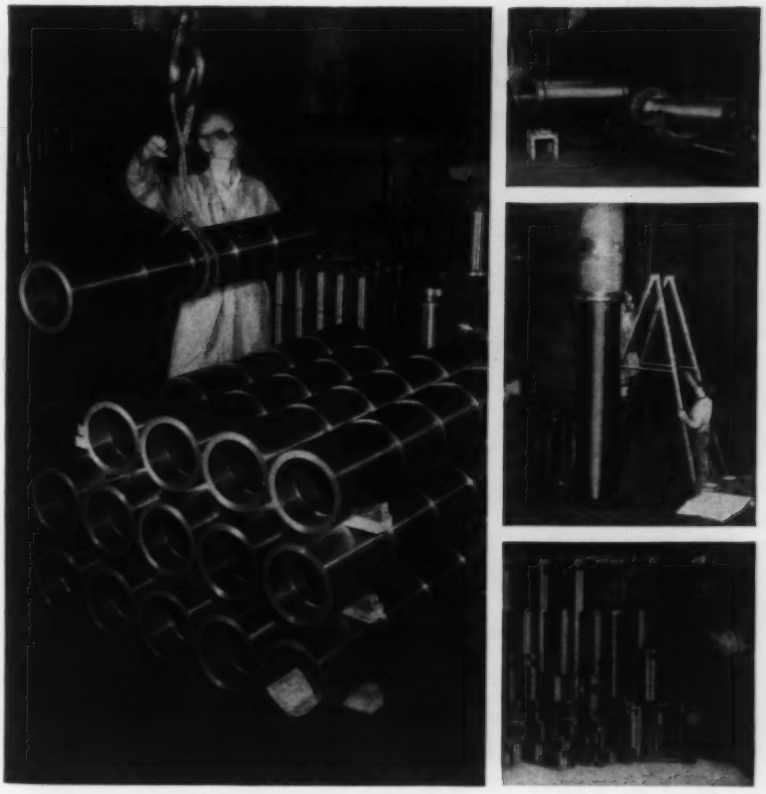
is invisible from the outside and is maintenance-free. **Southco Div., South Chester Corp.**, 3rd St. & N. Governor Printz Blvd., Lester, Pa. C

Circle 651 on Page 19

High-Pressure Hose

for 3000-psi aircraft systems

New spiral-wrap, high-pressure hose of Teflon is designed for 3000-psi aircraft systems. Spiral construction prevents brinelling of the stainless-steel wire, eliminates wire stress concentration, and provides optimum strength and flexibility. Fittings are leakproof and reusable. Metal-to-metal line seal in the fitting, combined with a lip seal



You save 5 ways with

SHENANGO CENTRIFUGAL CASTINGS

By using Shenango centrifugal castings for essentially symmetrical parts, you will gain considerable savings because:

1. **The Shenango process automatically eliminates hidden defects in the metal . . . insures fewer rejects.**
2. **No patterns required . . . an important saving, particularly on special or small quantity runs.**
3. **Finer, more uniform grain structure means smoother, faster machining, better control, and a higher rate of completion.**
4. **With Shenango centrifugal method control, there's less excess metal to be machined away, less metal to buy and ship!**
5. **Because of their homogeneous, pressure-dense qualities, Shenango centrifugal castings are stronger, have better wear resistance and require less frequent replacement. Maintenance cost is cut!**

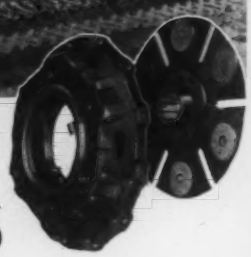
Check with Shenango on centrifugally cast parts for your needs —large or small castings . . . rough, semi-finished or precision-machined . . . ferrous or non-ferrous. They'll cost you less in the long run. For bulletins, write to: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, Ohio.

SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

Circle 498 on page 19

ROCKFORD



MORLIFE® CLUTCHES

Keep Heavy-Duty Machines 400% More Hours ON the Job 90% Less Time IN the Shop

Reports from a wide range of users state that MORLIFE clutches serve from four to ten times longer than previous types of friction clutches using organic facing materials. *Adjustments and plate replacements have been reduced to one-tenth those required by previous clutches.* The longer on-the-job hours and increased pay loads which MORLIFE clutches make possible furnish a competitive advantage for machines in which these NEW clutches are used. Increased clutch life results in decreased operation cost of vehicles or equipment. Let our engineers show you how *your* product will benefit through using MORLIFE clutches.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

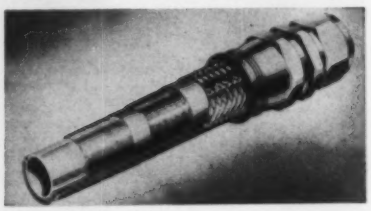
Speed Reducers

ROCKFORD B-W BORG-WARNER

CLUTCHES

New Parts

formed by the tube of Teflon between the nipple and the sleeve of the fitting, assures positive grip and protection against fitting blow-



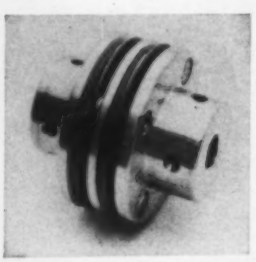
off. Hose functions in temperatures from — 100 to 500 F. **Aeroquip Corp.**, Jackson, Mich. H

Circle 652 on Page 19

Miniature Couplings

for ⅛ to ½-in. shaft diameters

Miniature flexible couplings provide a flexible connection for miniature electromagnetic clutches and brakes. They are available in two models with two sizes for each model, ranging from 15/16 to 1-15/16 in. OD for shaft diameters from ⅛ to ½ in. Couplings transmit 30 to 45 lb-in. torque at high speeds. They are torsionally rigid with no blacklash, and provide smooth, constant drive. Couplings absorb angular misalignment



to 7½ deg, lateral misalignment to 0.015 in., and axial movement to 0.060 in. in a single unit. They also dampen vibrations effectively. **Dial Products Co.**, 9 Avenue E, Bayonne, N. J. D

Circle 653 on Page 19

Synthetic Rubber Compound

for water-resistant seals

New synthetic rubber compound, designated 37-021, provides water-resistant seals in applications such as pump seals and impellers, liquid level switch diaphragms, water

Photo: Courtesy Sikorsky Aircraft Division, United Aircraft Corp., Bridgeport, Conn.

Special Quality Ostuco Tubing HERE

meets exacting specifications for Sikorsky

SALES OFFICES:
BIRMINGHAM
CHARLOTTE
CHICAGO (Oak Park)
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PITTSBURGH
RICHMOND
ROCHESTER
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ST. PETERSBURG
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TULSA
WICHITA
CANADA:
RAILWAY & POWER ENGR. CORP., LTD.
EXPORT:
COPPERWELD STEEL INTERNATIONAL COMPANY
225 Broadway, New York 7, New York

Strength, lightness, concentricity, *highest metallurgical quality* — just some of the rigid requirements set up by Sikorsky for seamless steel tubing used in tail rotor drive shafts for S-55 Marine helicopters. Sikorsky engineers demanded a tube with special O.D. and wall tolerances, special straightness and suitable for 100% Magnaflux inspection to Sikorsky's own stringent specifications.

Ohio Seamless engineers and metallurgists tackled the problem and met these rigid mechanical and magnetic quality standards — with "Ohio Special Quality" tubing.

Even if you don't make helicopter components, this actual case history may trigger your imagination. We'd like to tell you more about Ostuco Tubing. Just contact our nearest sales office, or the plant at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

Navy and Army, too. Ohio Special Quality tubing is also used in Sikorsky S-55's adapted for the specialized needs of the Navy, Army and allied nations.

OSTUCO TUBING

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

AA-9829

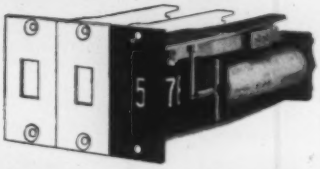
Circle 500 on page 19

SODECO's *New* Type 1TD

Electric Impulse Counter—

for: NORMAL COUNTING...

TRANSMISSION OF A NUMERICAL INDICATION
REMOTE PRESETTING FOR PREDETERMINING CONTROL



You can use these rugged single decade counters independently as decades or interdependently as a multi-digit counter to get practical solutions to an extremely wide variety of counting problems. Several different contact arrangements are available to solve a number of problems. For example, an interesting application is the use of any number of decades as a remote predetermined counter in which any preselected number can be set up quickly from a remote location and made to operate a signal at either or both locations when the count returns to zero. In this application, if desired, the preselected figure could be set up from a punched card. The counters are small, measuring only ⅜" x 1¾" x 4⅜", and are suitable for flush mounting. Fast, models are available with speeds up to 25 impulses/second. Power requirements are low—permitting their installation in electronic circuits. Long lived, tests indicate certainty of operation up to at least 50 million impulses.

Complete technical data is available, including circuitry recommended for a wide range of use. Write for Bulletin E-19.

LANDIS & GYR, INC.

45 West 45th Street, New York 36, N. Y.

Circle 501 on page 19

MIL-Spec

military cases, transit cases, combination cases

NO TOOLING COSTS!

using Zero standard deep-drawn aluminum boxes

Choose from more than 1400 standard sizes and save tooling cost. All can be trimmed and modified to your specification by secondary operations...brackets and fasteners installed, holes and louvers punched, welding, painting, etc. Choose from rectangular, round, square boxes and covers. Custom deep drawn parts at nominal cost using exclusive ZERO-method tooling—send your print or contact your local ZERO representative for a quotation.

Write for complete new ZERO catalog

ZERO MANUFACTURING COMPANY

1121 CHESTNUT, BURBANK, CALIFORNIA

New Parts

valve seals, oil slinger rings, dish washer, disposal, and water conditioner seals. Material also has basic oil resistance, making it suitable for agitator-shaft seals and back-up gaskets. Custom-molded parts and O-rings in all standard sizes are available. **Parker Rubber Div., Parker-Hannifin Corp.**, 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 654 on Page 19

Gate Valves

of aluminum alloy

Aluminum-alloy gate valves range in size from ½ to 24 in. They include types for every requirement where aluminum piping systems are

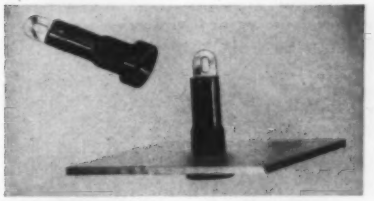
used. Valves incorporate fully revolving, double-disc, parallel-seat operation. **Darling Valve & Mfg. Co.**, Williamsport, Pa. E

Circle 655 on Page 19

Nylon Jack

one-piece unit is vibrationproof

Pushlock one-piece molded-nylon tip jack requires no threads, nuts, or lock washers. When fluted nylon body is mechanically pushed through ¼-in. cabinet or chassis hole, flutes compress and then expand to provide positive holding action that requires approximately 50-lb pull to release. Jack resists corrosion, chemical attack and fungus, and has excellent insulating properties and maximum strength. It is suited to mobile electrical and electronic equipment, airborne and marine service, and other installations subject to shock and vibration. Component accommodates



0.081-in. diam tip plug and is rated at 10,000 v dc. Black, yellow, red, and blue jacks are available. **Whitso Inc.**, Dept. MDC, 9330 Byron St., Shiller Park, Ill. I

Circle 656 on Page 19

Mylar Polyester Film

withstands direct sunlight for extended periods

Weatherable Mylar polyester film increases the versatility of plastic film for outdoor uses. Material withstands direct exposure to sunlight for extended periods. Outdoor life for the film in 5-mil thickness is 5 yr. Film has high tensile strength, clarity, and durability under extreme temperatures. Thin gage (1 mil) weatherable film, laminated to various backings, can be used as a surfacing material for decorative and trim applications. **E. I. DuPont de Nemours & Co.**, Wilmington 98, Del. C

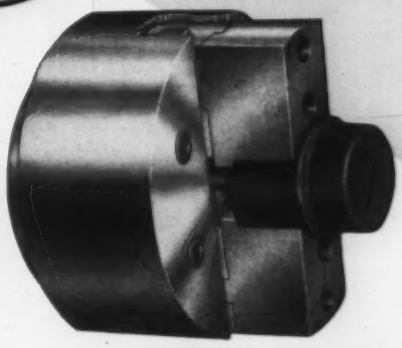
Circle 657 on Page 19

Immersible Motor

for close coupling to agitators or pumps

Flange-mounted immersible motor is designed for close coupling to agitators or pumps in sewage sumps, chemicals, water, and abrasive industrial oils. It is available in ¾ to 40 hp ratings, both single and polyphase. Features include leak-tight construction, neoprene breathers, waterproof cable connection, and corrosion-resistant

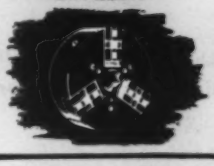
S-P POWER CHUCKS



for more gripping power– higher production

Famous S-P cam and lever design holds the work tighter, permits cost cutting heavy feeds and multiple cuts. S-P cam and lever design also resists opening of jaws by centrifugal force or diminishing air pressure . . . an important safety factor. Balanced for high rpm.

S-P SELF-CENTERING CHUCKS are built in Universal American Standard models, sizes 6" – 8" – 10" – 12", and Serrated models in 8" – 10" – 12" sizes. Two or three jaws.



S-P COMPENSATING CHUCKS grip out-of-round work with equal pressure on each jaw. Available in 8" – 10" – 12" sizes, two and three jaw models, American Standard or Serrated.

S-P ROTATING CYLINDERS

Air and Hydraulic

Adequate stroke for long jaw travel of S-P Chucks. Balanced for high rpm on machine tools and other applications. Details in Catalog No. 105 (Air) and Bul. 201 (Hydraulic).

S-P Power Chucks are installed as original equipment by Bardons & Oliver, Cleveland Automatic, Cone Automatic, Ex-Cell-O, Jones & Lamson, Monarch, Warner & Swasey . . . and many others. Representatives in principal cities. Prompt deliveries. Send for catalog No. 105. The S-P Manufacturing Corporation, 30201 Aurora Rd., Solon, Ohio.

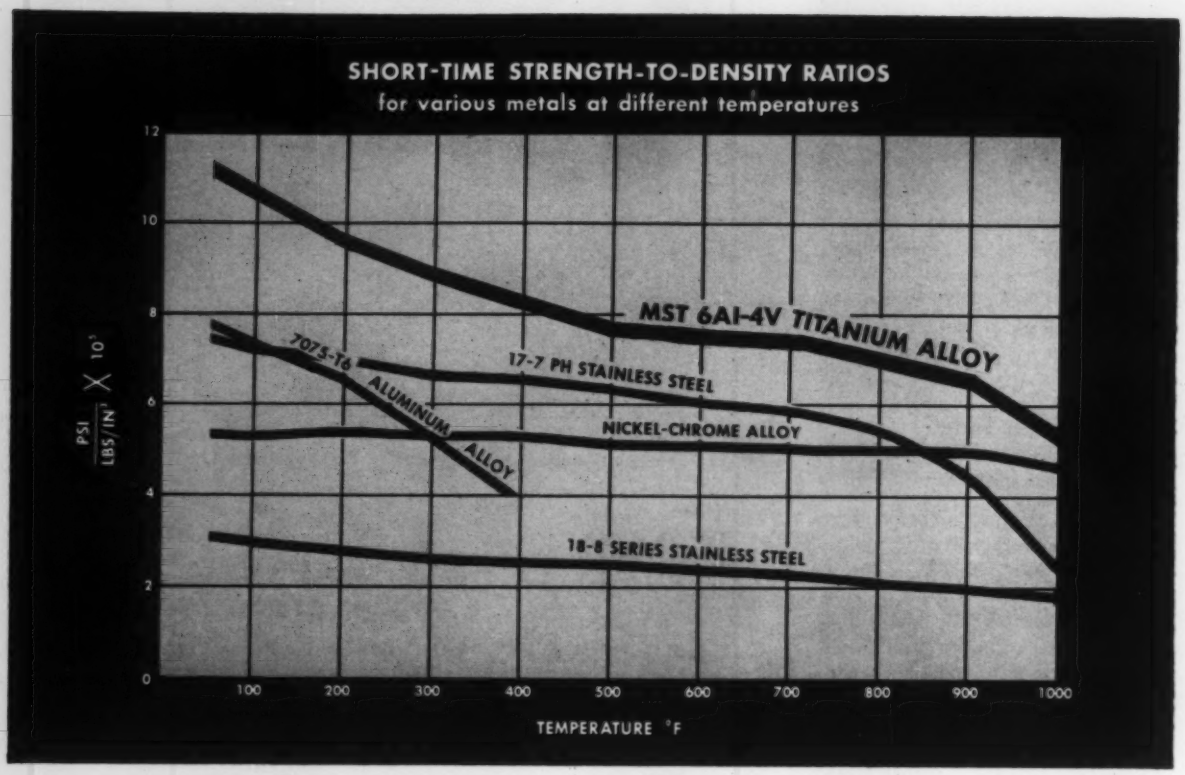
SPecify SP

THE S-P MANUFACTURING CORP.
SOLON, OHIO • IN GREATER CLEVELAND
ESTABLISHED 1916 A BASSETT COMPANY

NON-ROTATING AIR AND HYDRAULIC CYLINDERS • ROTATING AIR AND HYDRAULIC CYLINDERS
POWER CHUCKS • COLLET AND DRILL PRESS CHUCKS • AIR PISTONS, VALVES, ACCESSORIES

Circle 503 on page 19

Progress with **TITANIUM**



TITANIUM ON TOP

in medium-high temperature range

Today's most popular titanium alloy, MST 6Al-4V, excels all other metals in strength to density ratio through 900°F. At room temperature, considering only strength, a part made of this alloy need have only 60% of the weight of the equivalent part in stainless steel.

Performance for extended times at elevated temperatures is likewise good. In typical creep tests, with 1% permanent deformation allowed, MST 6Al-4V alloy shows 100,000 psi allowable stress at 750°F for 1 hour; 77,000 psi at 100 hours; 65,000 psi at 1000 hours.

Meanwhile new alloys extending the elevated temperature usefulness of titanium—to as high as 1000°F—are now emerging from the laboratory into production.

Write Dept. B-1 for copy of "Titanium Alloy Properties"

SELECTION GUIDE TO MST ALLOYS

Typical Mechanical Properties of Annealed Titanium and its Alloys

	Form	Ultimate Tensile Strength, psi	Yield Strength, psi	Elongation %*
COMMERCIALLY PURE TITANIUM				
MST Grade III	Sheet, Bar	70,000	50,000	25
(3 different strength levels)	Sheet, Bar	85,000	65,000	23
	Sheet, Bar	100,000	80,000	20
TITANIUM ALLOYS				
MST 6Al-4V				
Annealed	Bar	140,000	130,000	15
Age hardened (1)	Bar	165,000	155,000	12
Age hardened (2)	Bar	180,000	165,000	10
Annealed	Sheet	140,000	125,000	12
MST 3Al-5Cr	Bar	155,000	145,000	13
MST 4Al-4Mn	Bar	150,000	140,000	14
MST 8 Mn	Sheet	137,000	125,000	16

(1) 1650°F—1 hour—WQ; 1100°F—2 hours—AC
(2) 1700°F—1 hour—WQ; 1000°F—8 hours—AC

WQ—Water Quench
AC—Air Cool

* Values for 1" on bar and 2" on sheet

MALLORY-SHARON

METALS CORPORATION • NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

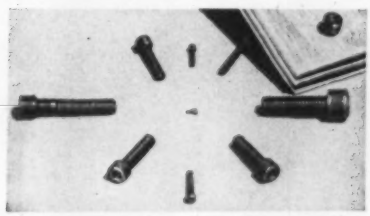
Circle 504 on page 19

parts. Motor shaft is directly attached to impeller, eliminating intermediate bearings, couplings, shafting, and special bases. **Louis Allis Co.**, Dept. P, 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 558 on Page 19

Cap Screws

are cold-forged, socket-head units



Cold-forged, socket-head cap screws are available in sizes No. 8 to 5/8 in. diameter in alloy steel. Chip-free, perfectly formed socket provides maximum strength and full gripping area on hex keys. Isothermal heat treating provides additional strength. **Set Screw & Mfg. Co.**, Bartlett, Ill. I

Circle 659 on Page 19

Variable Transformer

delivers 1.5 amp at any brush setting

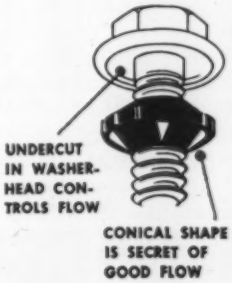
Brush arm of the VT1R5 variable transformer carries no current. A pigtail shunts current from brush directly to large copper graphite slip ring. Springlike brush arm provides completely independent

contact pressure. Ceramic hub aligns and mounts brush arm and provides 3000 v ac insulation between parts at line potential and shaft assembly. Unit delivers 1.5 amp at any brush setting. Internal stop eliminates the possibility of damage to brush and

One of the outstanding advantages of Townsend Tuff Tite fasteners is that they provide an economical means for leakproof joining of metal, asbestos, porcelain or plastic. The pre-assembled conical neoprene washers flow into the holes as the fasteners are seated, filling them and making waterproof seals. Tuff Tites are effective for any application requiring leakproof joints, such as those needed in the construction or appliance industries.

Tuff Tite advantages include ease and economy of installation, surface protection and vibration resistance. Standard items are immediately available from jobbers and warehouses. Tuff Tites are also available in numerous special designs to suit any application need.

If you are joining metal, plastic, porcelain or asbestos, you should know about Townsend Tuff Tites. Your Townsend representative will be glad to discuss them with you, or we will send you complete literature. Townsend Company, P. O. Box 237-E, New Brighton, Pa.



The Fastening Authority

Townsend

COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Cherry River Division • Santa Ana, California

In Canada: *Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario*

Circle 505 on page 19

Endurance RATED COUNTERS

Stroke and Revolution Counters for the *Toughest* Jobs

- **200 Million Count Life**
- Rugged, oversize shaft and bearings
- Shakeproof—only one screw in counter assembly.
- All steel housing with snap-on cover—chrome plated.
- Reliable — no skip or over-count.
- Tamperproof reset.

Thousands used in Automobile and Aircraft factories; in stamping, metal working, die casting and plastic molding plants; in foundries, printing plants and factories.

PIC-600 Electric Counters

Basemount
Knob reset

- **50 Million Count Life**
- 7 watts power consumption—operable in plate circuit of electronic tubes.
- 1000 CPM rating—reliable to 1600 with suitable actuation.
- Quiet—no AC hum.
- Balanced armature—for reliability on airborne equipment.

Also endurance rated counters for all purposes. See your PIC Distributor or write for catalog.

Production Instruments
DIVISION OF GENERAL CONTROLS CO.
8062 F McCormick 3lvd., Skokie, Ill.

42 Branch Offices and Representatives serving USA and Canada

Circle 506 on page 19

New Parts

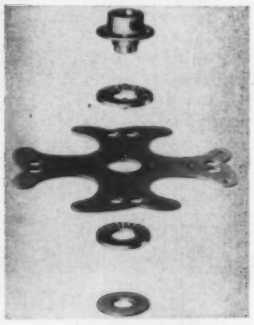
brush arm from application of torque at rotation limits. Reversible, direct-reading dial, calibrated to 120 on one side and 132 on the other, permits direct setting to the desired voltage for line or over-voltage connection. **Ohmite Mfg. Co.**, 3667 Howard St., Skokie, Ill. J

Circle 660 on Page 19

Resilient Fan Hub

combines high torque with low noise level

New resilient neoprene fan hub combines excellent noise reduction with starting-torque rating ranging to 20 lb-in. starting torque. High-torque type of the same basic design provides starting torques to



75 lb-in., permitting use of a soft hub in larger fan sizes. Eight driving lugs engage the spider and hub retainer. **Torrington Mfg. Co.**, Torrington, Conn. B

Circle 661 on Page 19

Temperature Control

for use in hazardous locations

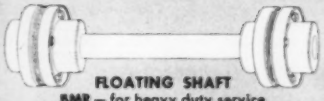
E95 explosionproof remote-bulb temperature control is a sensitive, compact unit for use in hazardous locations where explosive vapors or gases are present. Remote bulb thermal and control head are connected with capillary tube of varying lengths. Thermal system consists of a bulb, capillary tube, and bellows filled with a temperature-sensitive liquid. Heating or cooling of the liquid expands or contracts bellows, operating a snap-acting switch at a preset temperature. Temperature settings are made with an external adjustment knob and calibrated dial. Models

Specify THOMAS ALL METAL FLEXIBLE COUPLINGS FOR MAINTENANCE FREE POWER TRANSMISSION on PUMP, COMPRESSOR, MARINE and OTHER DRIVES

"TOMALOY" FLEXIBLE DISC RINGS

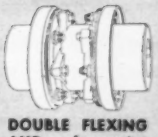
DBZ — for high speed, heavy duty drives

Thomas' 40 years of flexible coupling experience is at your disposal to help you meet ordinary applications or special variations for unusual cases.



FLOATING SHAFT
BMR — for heavy duty service with excessive misalignment

SINGLE FLEXING
SS — for engine-driven generator sets with out-board bearings



DOUBLE FLEXING
AMR — for engine and medium speed drives

UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES.

1 Freedom from Backlash Torsional Rigidity
2 Free End Float
3 Smooth Continuous Drive with Constant Rotational Velocity
4 Visual Inspection While in Operation
5 Original Balance for Life
6 No Lubrication
7 No Wearing Parts
8 No Maintenance

Write for Engineering Catalog

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U. S. A.

Circle 507 on page 19

are available with adjustable range spans of 100 or 200 F, between limits of −150 and 650 F. **United Electric Controls Co.**, 79 School St., Watertown, Mass. B

Circle 662 on Page 19

Nylon Plate

is 10 in. wide and up to 4 ft long

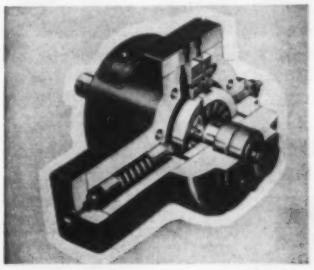
Polypenco nylon plate is now available in thicknesses from 3/16 to 1½ in. in Nylon 101 and Nylatron GS formulations. Standard width is 10 in. and lengths range to 4 ft. Plate is used in a variety of industries for parts such as wear liners or pads, stripper knives or scraper blades, equipment slides, and insulator panels. It is readily machined on milling and shaping equipment. Properties include high wear resistance and resilience, low surface friction for use where lubrication is undesirable, nonscratching or galling, and ability to deaden sound. **Polymer Corp. of Pennsylvania**, 2140 Fairmont Ave., Reading, Pa. C

Circle 663 on Page 19

Vane Pump

for hydrauic-circuit power applications

Model S variable-volume, vane-type pump with 10-gpm capacity



SEALING DOMESTIC APPLIANCES IS A REAL CHALLENGE, TOO!
Standard 6A Seal with specially designed seat conforming to impeller contour so as to promote good water flow characteristics.
Limited axial room and large diameter are mechanical requirements in this washing machine seal. Design features multiple spring construction for even face loading.
FIVE ADAPTATIONS OF THE John Crane TYPE 6A SEAL for four different appliance manufacturers
Seal features outer periphery face construction to best service garbage disposal conditions.
Two sealing points in a washing machine with widely differing physical limitations, yet seals for both retain full advantage of diaphragm action, shouldering points and positive drive.

Soapy water, detergents, bones, grit and lint . . . all these combine to make appliances a hard-to-handle sealing problem. Add that to a very limited space factor, and you've got a real set of conditions on your hands.

"John Crane" engineers have solved these problems and thousands of other shaft sealing applications on all types of commercial and industrial equipment. We know that we can be of the same help to you.

That's why . . . as one design engineer to another . . . we urge you to let us work with you in adapting or developing the proper seal for your application.

Tell us about your requirements or write for our fully illustrated Bulletin S-204-3 on "John Crane" Shaft Seals.

Crane Packing Company, 6425 Oakton Street, Morton Grove, Illinois, (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

THE WORLD'S FIRST CARD-OPERATED MILL,

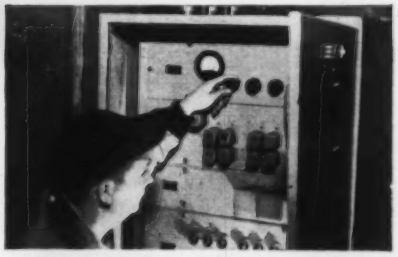
PROMISES YOU BETTER STEEL—AUTOMATICALLY

HIGHER QUALITY

MORE
UNIFORM SIZE

BETTER
PHYSICAL PROPERTIES

New method provides a large file of schedules for various types of steel.



General Electric engineers, working closely with AL personnel, developed and installed the control systems which regulate the mill.

Better quality, more uniform steel is the result.

A NEW punch-card control system, recently installed on the 56″ universal roughing mill at Allegheny Ludlum's Brackenridge, Pa. plant, is advancing mill standards of quality control.

Here's how it works: Allegheny Ludlum rolling experts predetermine optimum rolling procedures for the type of steel desired and translate this data into punches on an IBM card. These punches represent the proper screwdown settings, mill speed and number of passes. When the mill schedule calls for it, the mill operator in the pulpit simply selects the proper card, inserts it into the card reader, and he is ready to roll. As the operator makes each pass, the mill is automatically adjusted for each additional pass required. The rolled material is held uniformly to desired dimensions, and day in, day out it proves to have better, more constant physical properties.

It's easy to see how this kind of progress fits into your interest in consistent high quality. By performing rolling operations exactly the same way time after time, this new unit further assures Allegheny Ludlum customers that they are getting the best possible product from the industry's pioneer producer.

Let us talk over your requirements with you. Write us, or call the Allegheny Ludlum sales office nearest you, and an AL sales engineer will help you with any problem. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania.***

WSW 6828

PIONEERING on the Horizons of Steel

Allegheny Ludlum

AL ALLEGHENY LUDLUM

Circle 509 on page 19

operates at 1000 psi and 1800 rpm. It is for a variety of hydraulic-circuit power applications. Pump is subplate mounted. **Racine Hydraulics & Machinery Inc.**, 2000 Albert St., Racine, Wis. K

Circle 664 on Page 19

Proximity Coil

incorporates nonmetallic housing

Atcotran proximity coil has an entirely nonmetallic housing consisting of nylon liner, bakelite bobbin, and bakelite shell. Zinc and lead parts passing through the coil actuate the control relay by producing a phase shift. Winding consists of two aiding primaries and two bucking secondaries. Sen-

sitivity is controlled by adjusting a screw which distorts field of one primary and one secondary winding to unbalance system. Nonmagnetic material passing through coil balances system and actuates relay. **Automatic Timing & Controls Inc.**, King of Prussia, Pa. E

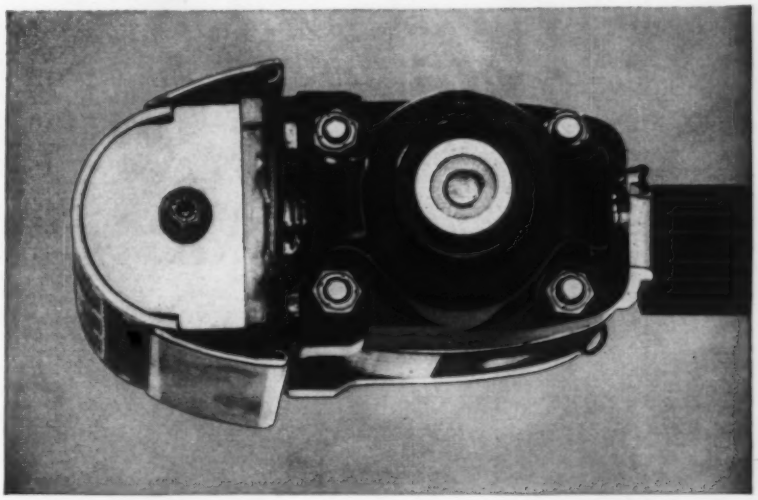
Circle 665 on Page 19

DC Torque Motors

in sizes from 0.05 to 500 lb-ft

Designed for direct mounting, these dc torque motors are for use in servo systems where direct drive is needed and where size, weight, power requirements, and response time must be minimized. Motors provide high angular acceleration by utilizing direct drive. They are available in torque ratings from 0.05 to 500 lb-ft. Basic ODs range from 1.9 to 30 in., and overall length from 0.500 to 6.2 in. Winding impedance levels can be

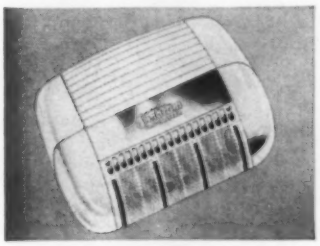
FASTENER PROBLEM



Self-locking fasteners for limited clearance applications

The cutter shaft of the Sunbeam Electric Shaver moves the cutting blades at about 9000 RPM. The double nuts previously used to fasten the pitman arm to this shaft had to be really tight. With the pressure of high volume production, improper tightening sometimes caused bent shafts—and frequent thread stripping.

A single true miniature ELASTIC STOP® nut, only .080" high and .125" across flats (ESNA No. 99-1660-12, 1-72 thread) is used to replace the double nuts. The action of ESNA's red elastic locking collar permits locking anywhere on the shaft for simple and completely accurate adjustment . . . and eliminates thread stripping. This simple, direct locking action avoids production-time losses due to bending; and saves the cost of the rejected shafts as well.



A separate series of reduced-dimension hex nuts are used on the "field" studs fastening motor to frame (ESNA No. 99-2399-38). This size 3-48 nut is .130" high and .187" across flats. The stop nut eliminates lock washers and further shortens assembly time. Solution of this multiple fastener problem illustrates ESNA's ability to supply an efficient, vibration-proof, self-locking fastener to meet almost any dimensional requirements.

MAIL COUPON FOR DESIGN INFORMATION

ESNA

Dept. N91-24, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send me the following information:

☐ Details on ESNA miniature and reduced dimension nuts

☐ ELASTIC STOP® nut bulletin

☐ Here is a drawing of our product. What fastener would you suggest?

Name_____ Title_____

Firm_____

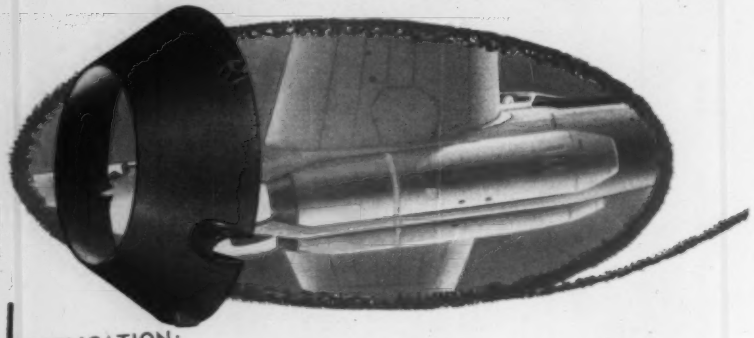
Street_____

City_____ Zone____ State_____

Circle 510 on page 19

THE SHAPE OF THINGS IN MOLDED SILICONE

SILI-CONE PROVES REAL COOL FOR JET AIRCRAFT EQUIPMENT



APPLICATION:
Thermal barrier for jet aircraft accessories.

PROBLEM:
The original part, along with drawings and molds, was presented to Acushnet by a well-known manufacturer of accessories for conventional and jet aircraft with orders to continue development with Dow-Corning 301 compound. The idea was to attain a part that would provide maximum physical properties at elevated temperatures of over 800°F.

SOLUTION:
Overcoming the high bulk factor of the compound was accomplished through the design and construction of a preform. Running the original mold in a special hydraulic ram equipped with controls permitting a wide range of temperatures and pressures, provided the necessary information in curing this compound. The resultant cure times and pressures enabled Acushnet engineers to design and construct a compression mold of hardened steel that made this part possible. Included in this project were small gaskets molded from Dow-Corning 301 that proved superior to metal in high heat insulating applications.

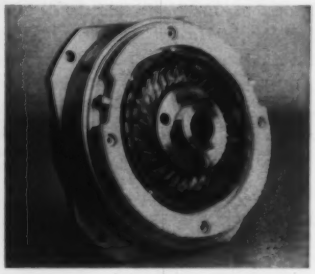
Pioneers in the advanced mold techniques and custom compounding of silicones, Acushnet now offers you immediate technical assistance in the molding and finishing of silicone resins.
Send for Acushnet "Rubber Data Handbook."

What's Your Shape?

Acushnet

ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS
... *Precision Molded* **RUBBER, SILICONES - "APCOTITE" BONDING**
Address all communications to 762 Belleville Ave., New Bedford, Mass.

New Parts



achieved over a wide range. **Inland Motor Corp.**, 23 W. Washington Ave., Pearl River, N. Y. D

Circle 666 on Page 19

Spring-Steel Clip

retains 1½-w resistors to panels

Spring-steel Speed Clip is snapped into a panel hole, and a 1½-w resistor is then inserted into the clip and held firmly under live spring tension. Clip retains resistors of 1½-w size to steel, phenolic, fiber, or plastic panels. Elongated cutout in clip provides unobstructed view of color code. Wrap-around characteristic of the

reusable tubular-shaped clip provides fast heat dissipation. **Tinnerman Products Inc.**, Box 6688, Cleveland, Ohio. F

Circle 667 on Page 19

Germanium Junction

is 500-amp single-crystal unit

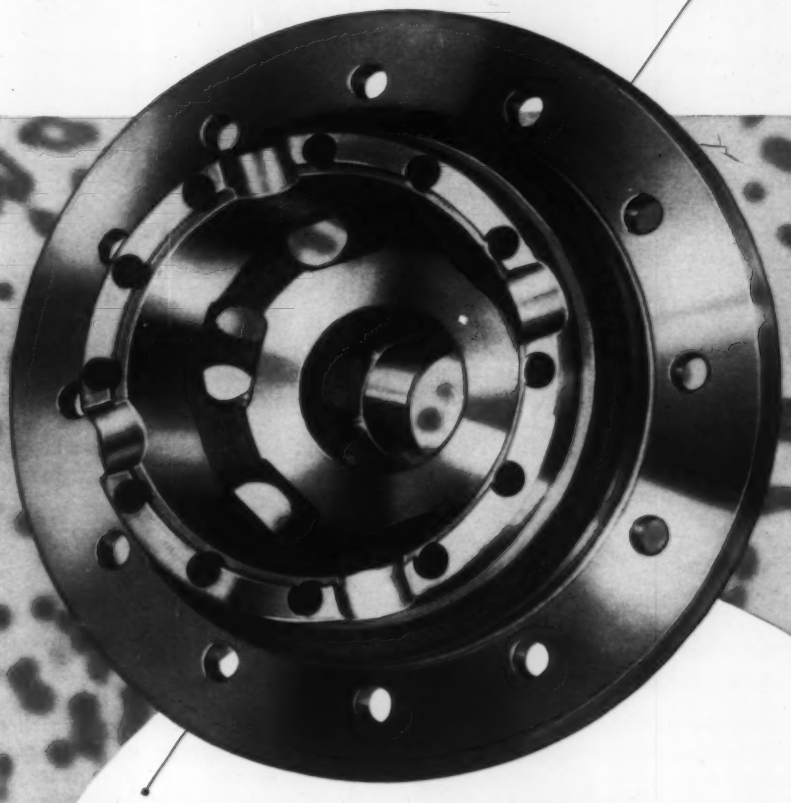
This 500-amp single-crystal germanium power junction is free of internal stresses, providing ability to withstand acute thermal shock. Large active area results in a low current density. All-welded and hermetically sealed, junction is alloyed during hermetic sealing without the use of active chemicals,

is your problem

machinability?

NATIONAL HTM CASTINGS

are the answer



Important Physical Properties	
Brinell	163 to 302*
Yield, psi	48,000 to 85,000*
Ultimate, psi	70,000 to 110,000*
Elongation, %	7 to 2*

**Depending upon grade*

There are many reasons for specifying HTM (Pearlitic Malleable) castings for your product. One is *machinability of 70-90 percent* (B1112 steel = 100).

But there are many other equally valid reasons. High ultimate strength . . . extreme wear resistance under heavy loads and high speeds . . . non-seizing qualities . . . air or liquid quenching . . . ability to be smooth-finished.

So when you're looking over the materials field, don't overlook the advantages of HTM castings. For HTM metal can be cast by either the shell mold, CO_2, or green sand methods. This means production costs tumble . . . performance and saleability of your product go up.

NATIONAL MALLEABLE and STEEL CASTINGS COMPANY

Established 1868 — *Cleveland 6, Ohio*

AA-6832

The nation's largest independent producer of malleable and pearlitic malleable

Circle 512 on page 19

NOW-A Better Rotary Joint!

Patent Pending

SIZES
½" ¾" 1" 1¼"
1½" 2" 2½" 3"

NEW BARCO TYPE C Rotary Joint

"SUPER" Performance and Construction —at no extra cost!

"CRACK-FREE" CHROME PLATED SLEEVE—A standard Barco feature. "Crack-free" chrome on rotating sleeve minimizes corrosion, friction, wear. Stainless steel spring also standard.

RESISTS SEAL RING BREAKAGE—The spherical seal ring is under compression, not *tension*, loading. Seal withstands shock loads and alternating hot and cold service.

NO LUBRICATION NEEDED—Spherical seating seal self-adjusting for wear.

WIDE SPACED BEARINGS—Two, instead of one . . . increased bearing area.

200 P. S. I. STEAM RATING—Heavy duty service at *no extra cost*. Lowest friction. Hydraulic loads to 400 psi; temperatures to 450°F, special to 500°F.

FOR ALL SERVICES—One basic style of joint for single flow or syphon flow . . . one basic seal for all services. AVAILABLE NOW.

for

STEAM
WATER
OIL
AIR or GAS

SEND FOR NEW CATALOG 310 TODAY.

PRODUCTS BACKED BY EXPERIENCE
BARCO
ANNIVERSARY 1900 50TH 1950

BARCO MANUFACTURING CO.
506C Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
In Canada: The Holden Co., Ltd., Montreal

New Parts

reducing possibility of contamination during processing. Junction is used in 500-amp air-cooled and 670-amp liquid-cooled junctions, available for applications in electrochemical, metal-refining, and other industries requiring heavy current at voltages from 26 to 66 v. **International Rectifier Corp.,** 1521 E. Grand Ave., El Segundo, Calif. L

Circle 668 on Page 19

Subminiature Relays

incorporate double spiral springs

Series 33 subminiature relays provide excellent reliability and long switch operation. Snap-over action of relay switch eliminates floating contact, insures high impact and contact wipe, and rapid flight time. Double spiral springs pro-

vide nonresonance over a frequency range of 0 to more than 3500 cps. They provide good armature activity and stability from movement in undesirable planes. **Phillips Control Corp.,** 59 W. Washington St., Joliet, Ill. I

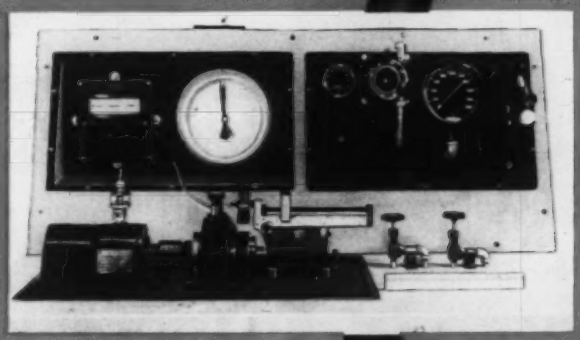
Circle 669 on Page 19

Tubing

is pure white and opaque

Pyroceram tubing, in diameters from ⅛ to ¾ in., is for industrial applications such as heat exchangers and process piping. Tubing is pure white and opaque, and

Low Cost Rotary Seals



Precision test stand especially developed to test efficiency of "O" rings as low cost rotating shaft seals.

Precision "O" Rings from Compound 158-80 provide the answer to a problem for a manufacturer of Oil-Hydraulic Pumps.

1. Eliminated costly hand lapping
2. Reduced friction—increased life
3. Sealed 2000 P.S.I.

Compound 158-80, with built in lubrication, is especially suitable for those jobs where friction is a problem. They are compression molded, rigidly inspected —the finest made!

Have a sealing problem? You'll find the answer at Precision! There's a Precision engineer ready to help you in "O" Ring specification and product design.

Get your free copy of our Engineering Data Sheet on Compound 158-80.

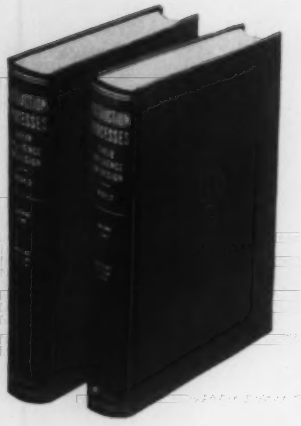
Specify Precision—first in quality

Precision Rubber Products Corporation

"O" Ring and Dyna-seal Specialists

Box 431, Oakridge Drive, Dayton 7, Ohio **Canadian plant at: Ste. Thèrése de Blainville, Québec**

how to design for LOW COST production



- 924 pages of fully illustrated text
- Covers 56 different processes
- Includes 9 major production areas

"PRODUCTION PROCESSES"

THEIR INFLUENCE ON DESIGN, by Roger W. Bolz

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The most practical books ever written on production processes and their influence on design . . . by one of the country's outstanding authorities on production processes, Roger W. Bolz.

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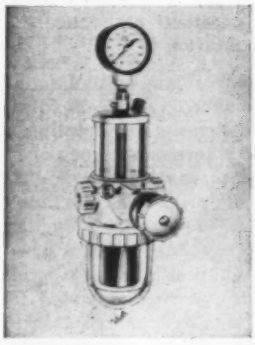
has thermal shock resistance equivalent to fused silica. Flexural strength of abraded tubing is 17,000 to 23,000 psi. Used in heat exchangers, tubing permits higher rates of heat flow per unit area, allows higher operating pressures, and lessens chance of damage to the unit by abrasive particles. **Corning Glass Works,** Corning, N. Y. D

Circle 670 on Page 19

Air-Control Device

is regulator, filter, and lubricator



Combination regulator, filter, and lubricator is a package unit for compressed-air operations. It accurately regulates to desired pressure, filters water and dirt from the air line, and lubricates the air stream with a fine, foglike oil mist. Regulator, which operates on a balanced-piston principle, provides regulation to zero, where it serves as a shut-off valve. Throw-away cartridges are used in the filter. External adjustment meters lubricant, which automatically enters the air stream as an oil mist. Unit is available in ¼, ⅜, ½, and ¾-in. pipe sizes. **Perfecting Service Co.,** 332 Atando Ave., Charlotte 6, N. C. A

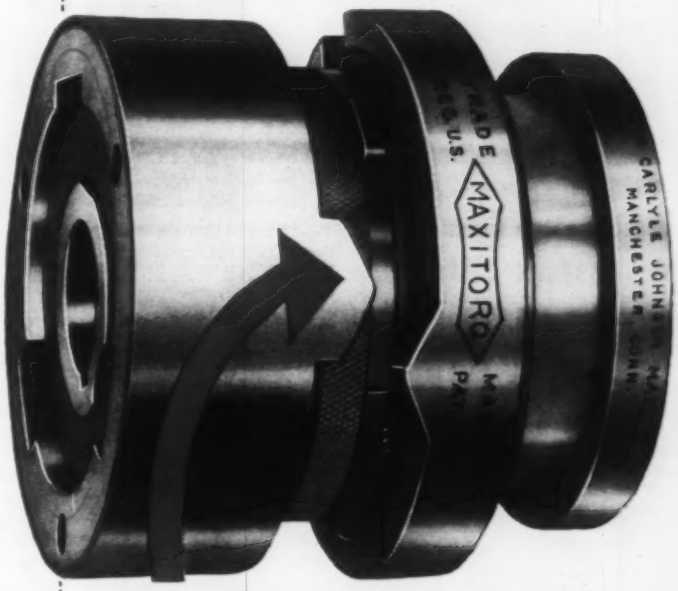
Circle 671 on Page 19

Teflon Lead Insulators

withstand 500-F temperatures

Teflon subminiature tube lead insulators are for missile guidance and military electronics systems. They have a high reliability factor, withstanding shock, vibration, and temperatures to 500 F. Insulators

PLUS protection against overload



Maxitorq

overload release clutches

Designers and builders have found MAXITORQ Overload Release Clutches the ideal way to provide dependable protection against overload conditions.

Unlike such devices as shear pins, the MAXITORQ Overload Release Clutch requires no dis-assembly or replacement after functioning. Once the cause of overload is removed or corrected, the machine may be re-started at once. Furthermore, MAXITORQ Overload Release Clutches may be adjusted for pre-determined overload protection.

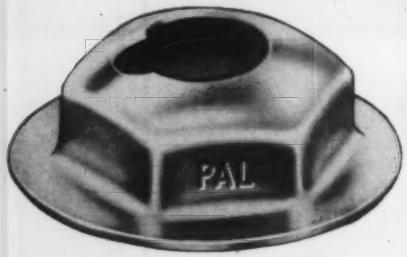
In addition, users enjoy the proved advantages of the MAXITORQ Floating Disc Clutch . . . smooth, positive engagement and release . . . "floating" neutral with no drag or heating . . . easy manual adjustment.

We will be glad to give you the benefit of our long and successful experience in clutch and brake design; the overload release clutches are only one of many advanced MAXITORQ developments in both manual and electrically operated applications. Ask for literature, or outline your problem . . . write Dept. MD-2.

THE CARLYLE JOHNSON MACHINE CO.
Manchester, Connecticut

2CJ58

Replace THREE fasteners with ONE WASHER TYPE PALNUT LOCK NUT



Washer Type PALNUT Lock Nuts combine the functions of a plain hex nut, lockwasher and flat washer in a low-cost, one-piece spring steel lock nut.

Slash assembly costs—gain assembly advantages on light sheet metal assemblies—parts—ornaments—moldings, etc.

Type D. Available in a variety of base diameters.

Type D, with Sealer. Bonded-in plastisol compound seals out dirt and water.

Grounding Type. Teeth in base cut through non-conductive coatings to form electrical ground. Available with sealer.

Spacer Type spans bosses or protruding elements. Available with sealer.

Type E has flattened top for use on electrical connections and assemblies.

- **Big Savings.** Washer Type PALNUTS cost much less than three separate fasteners—reduce parts and handling—cut assembly time—speed up production.
- **Fast Assembly.** A single PALNUT is picked up, started and tightened in one high-speed operation, using PALNUT magnetized socket wrenches in power tools. Spins on freely, seats with high torque, assuring fast, reliable power tool operation.
- **Tight Assemblies.** When tightened, spring locking action grips the screw thread, while spring washer base assures resilient contact against assembled parts.
- **Resilient Locking Action** absorbs shock of tightening, permits safe assembly of fragile or pliant parts.
- **Washer base spans holes and slots**
- **May be removed and re-used**

WRITE TODAY FOR FREE SAMPLES, stating types, sizes and intended application. Ask for our new Catalog 573-C, just published.

THE PALNUT COMPANY
75 Glen Road, Mountainside, N. J.

PALNUT® LOCK NUTS FASTENERS (PAL®)

Quick, secure fastening at low cost

New Parts

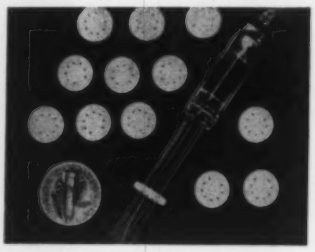


exhibit zero moisture absorption and low loss characteristics. **Fluorocarbon Products Inc., Div., U .S. Gasket Co.**, Camden 1, N. J. E

Circle 672 on Page 19

Heater-Element Alloy

has excellent resistance to oxidation

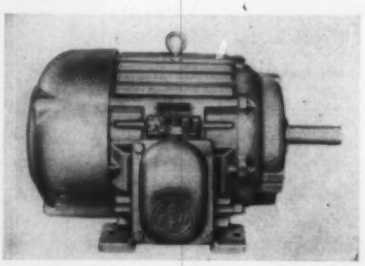
Iron - chromium - aluminum alloy, known as Alloy 835, is for use in electrical resistance-heating applications where continuous operating temperatures do not exceed 2250 F. Physical properties include high electrical resistivity, long life at high operating temperatures, and excellent resistance to oxidation. Alloy is not recommended for use in reducing atmospheres other than dry hydrogen. **Hoskins Mfg. Co.**, 445 Lawton Ave., Detroit 8, Mich. H

Circle 673 on Page 19

Explosionproof Motors

in fan-cooled and nonventilated models

Totally enclosed, explosionproof motors are designed to eliminate fires or explosions when motors must be operated in combustible or explosive atmospheres. Available in both fan-cooled and nonventilated models, they meet latest NEMA standards, and are UL approved for Class I, Group D, Class II, Group E, Class II, Group F, and Class II, Group G. Type KZCX fan-cooled motor (shown)



has ratings from 1½ to 30 hp. Type KZEX nonventilated type is available with 1½ and lower horsepower ratings. Single-row, deep-grooved ball bearings assure minimum of friction loss. Conduit box can be rotated around motor periphery to any of four positions, permitting the making of connections from either side, top, or bottom positions on motor. **Fairbanks, Morse & Co.**, 600 S. Michigan Ave., Chicago 5, Ill. I

Circle 674 on Page 19

Fused Mercury Relays

provide positive protection against overload

Fused mercury-plunger relays, which incorporate hermetically sealed mercury-to-mercury contacts, are unaffected by dust, dirt, moisture, and corrosion. They provide positive protection against overload. Relays are suitable for

use in motor control, lighting control, heater power, furnaces, radio and television power, refrigeration equipment, traffic controls, and welding equipment. Unit illustrated is EMF-1, for loads to 35 amp at 115 v ac. Also available are fused models of two and three-pole construction, for loads to 60 amp at 115 v ac. **Ebert Electronics Corp.**, 212-32 A Jamaica Ave., Queens Village 28, N. Y. D

Circle 675 on Page 19

Machine Tool Switch

controls up to four separate circuits

Precision limit switch controls up to four separate circuits for pilot

get pumping efficiency

...with I-R motorpumps

Here is a line of efficient, dependable centrifugal pumps that can add to the overall performance of the equipment you manufacture . . . Ingersoll-Rand Motorpumps — available in the widest range of types and sizes — are made to stand up under the most severe service; will provide the best in low-cost, low-maintenance operation.

Send for your copy of literature that contains complete performance and installation data.

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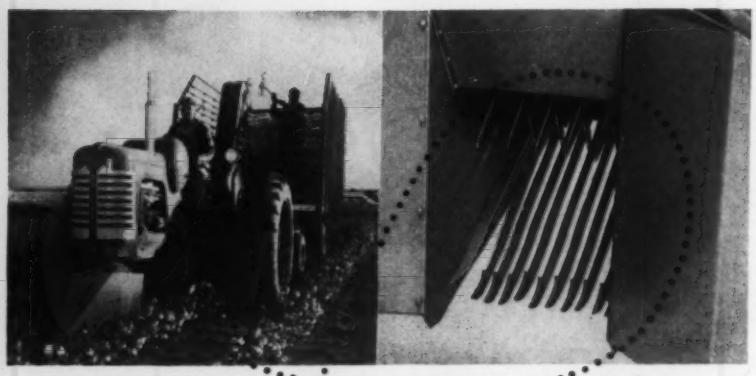


82% saved...
breakage stopped...
adjustability gained through
Malleable Iron

...all this achieved by Oliver Corporation for one part in their cotton stripper machine

This 30" tooth and 19 others like it in an Oliver Cotton Harvester, strip the cotton bolls from field plants. It is an unusual casting, only ¾" thick at the widest point except the mounting shank. Since making it of Malleable Iron, Oliver has saved 82% on the cost of each tooth, or $136.00 per harvester.

The cotton farmer benefits two ways: the tough malleable teeth do not snap off; and the improved mounting method now possible enables him to adjust their spacing for different types of cotton. *None of these malleable teeth, formerly made of another material, have broken in the harvesters built since their adoption.*

How about Malleable?

Thousands of important parts have been strengthened—improved in appearance—reduced in cost, by manufacturers in many industries. Write for our Value Analysis brochure, filled with examples.

Consult a malleable foundry engineer at the drawing board stage.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building **Cleveland 14, Ohio**

New Parts

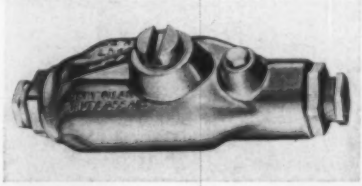
or line duty. Actuation is adjustable in a full 360-deg sweep, on two different planes. Double-action switch controls switch contacts when actuator is moved to either side of center or to at-rest position. Electrical rating is 2 hp 230 v ac, 1 hp 115 v ac, and 20 amp 125-250 v ac. **Acro Div., Robertshaw-Fulton Controls Co.,** Columbus 16, Ohio. G

Circle 676 on Page 19

Automatic Line Oiler

for use with air tools

LO 380 automatic line oiler is lightweight, easily adjusted, and refillable while in use. Positive type oil pickup feeds oil to the air tool; when oil supply is exhausted, air supply is cut off automatically. Unit has a 1-pt capaci-



ty. Oiler body is aluminum, and weighs 9 lb. **LeRoi Div., Westinghouse Air Brake Co.,** Milwaukee 1, Wis. K

Circle 677 on Page 19

Pressure Hinge

springless unit provides pressure-tight seal

Hinge-Lock is a high-strength hinge which applies pressure along the hinge line of hinged-cover containers and equipment cases. Springless unit insures a pressure-tight seal where gasketing is used. It resists impact and is unaffected by arctic temperatures. Positive locking is accomplished by hand

(Advertisement)

APPLYING RELIANCE V*S DRIVES IN CYCLING EQUIPMENT

BY
V. R. MURPHY, E.E.
Manager of V*S Products
Reliance Electric and
Engineering Company

Years of application experience have proved Reliance V*S Drives are ideal for powering cycling equipment. The all electric design is fast acting, acceleration times in tenths and hundreds of a second are common. V*S equipment lends itself to a variety of automatic controls.

V*S DRIVE COMPONENTS

A V*S Drive operates from standard a-c. power lines and consists of three basic components: d-c. drive motor, packaged motor controls and operator's control station.

Reliance drive motors change speed over a wide range, smoothly and without speed steps. The all electric design permits the inclusion of built-in dynamic or regenerative braking, giving fast, maintenance-free stopping power.

Motor-generator sets or electronic rectifiers, working from in plant a-c. power lines, form the nucleus of the motor control unit. A series of built-in controls regulate voltage and current in the system. With these controls, any required combination of speed, horsepower, torque and time characteristics are produced.

CYCLING WITH TENSION CONTROL

An example of simple, rapid cycling is shown in Figure 1. This is the operating cycle of a small winding machine that rewinds wax paper and similar material from large production rolls onto smaller rolls for retail sale. The operation requires a fast winding speed, as well as a slow speed for changing retail rolls. After the new roll is started, the productivity of the machine depends on how fast it can get to winding speed without tearing the material.

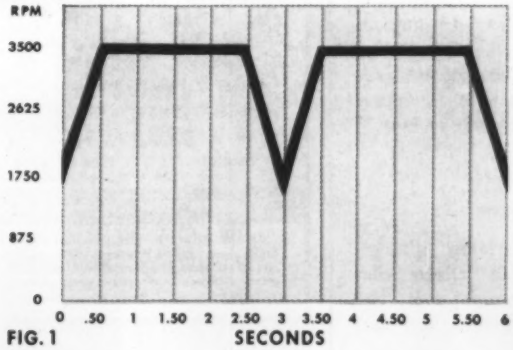


FIG. 1

A Reliance VST Control is used to force motor voltage to give optimum acceleration and deceleration rates. Selected rates can be designed into equipment to meet any cycling requirement. A description of this machine is found in Bulletin D-1532.

FORWARD AND REVERSE CYCLING

Another type of cycling operation is shown in Figure 2. This shows the cycle pattern of a flying cut-off on a continuous pipe mill. A V*S Drive automatically, measures the pipe length, starts the cut-off carriage and brings it to line speed, stops after cut-off and returns the carriage for another cut.

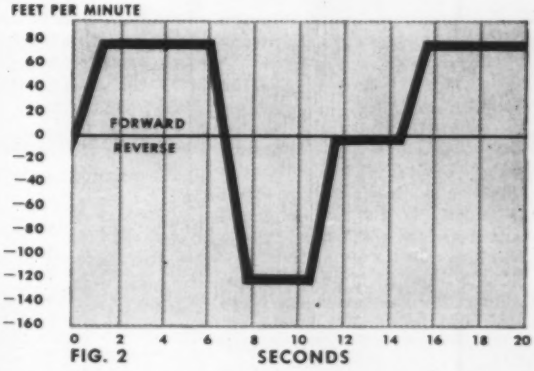


FIG. 2

A digital counter measures the pipe as it passes through the carriage. When the correct length has been fed through, the motor is forced and rapidly accelerated, bringing the carriage up to line speed. Using a dual tachometer matching system and a VSR speed regulator, the carriage speed is exactly matched to line speed during cut-off. After cut-off, the carriage is returned to its starting position, while the counter measures for another cut. A description of this drive is found in Reliance Bulletin L-2505.

These are two of the many types of cycling operations that utilize Reliance V*S Drives. The variety of Reliance V*S Controls, and the wide horsepower and speed ranges, make these drives applicable to any cycling operation. Cycling is only one operation for which the V*S concept is suited.

If you would like further information on how you can use V*S Drives when designing your product, contact your local Reliance representative, or write to the V*S Product Department. D-1581

RELIANCE ELECTRIC AND ENGINEERING CO.
Dept. 282A, Cleveland 17, Ohio
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in principal cities

Circle 520 on Page 19

4 Ounce Contact Force Makes Relays More Reliable

Contact force of 4 ounces per contact on 50 "G" models and 2 ounces per contact on 30 "G" models of "Diamond H" Series R and Series S miniature, hermetically sealed, aircraft type relays is one of the most important factors in their proven high reliability.

Though absolute reliability of any similar device is impossible to guarantee—a bitter fact of life recognized by all electronic engineers—close approach to this goal by the relays manufactured by The Hart Manufacturing Company is the basic reason they are found today on many of this country's headline-making missiles.

In addition to contact force far beyond that found on other relays, "Diamond H" relays have greater contact cleanliness. Self-contamination is virtually eliminated by a completely inorganic switch mechanism, as well as use of coil materials which will not dust, flake or out-gas.

Finally, the high degree of reliability that is designed into these relays is maintained in their manufacture by high quality workmanship and a stringent inspection policy at every stage.

In addition to missiles, and their ground control systems, Series R and S relays are designed for use in jet engine controls, computers, fire control, radar and similar critical applications.

4PDT units, they offer an extremely broad range of performance characteristics, including temperature ranges from —65° C. to 125° and 200° C.; ratings to 10 A., 120 V., A. C., and 26½ V., D. C., with special ratings to 400 ma. at 350 V., D. C., or down to millivolts and milliamperes. Dry and wet circuits may be safely inter-mixed.

For more information, write today for Bulletins R250 and S260. For quick facts about "Diamond H" switches, thermostats and other devices, ask also for a copy of the "Diamond H" Check List of Reliable Controls.

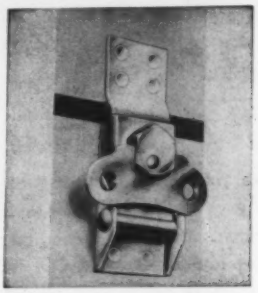
THE **HART** MANUFACTURING COMPANY

118 Bartholomew Ave., Hartford 1, Conn.
Phone JAckson 5-3491

Circle 521 on Page 19

New Parts

by a half-turn on wing nut. When pressure is released by a counter-turn, unit becomes a free-operating hinge. It is available in two



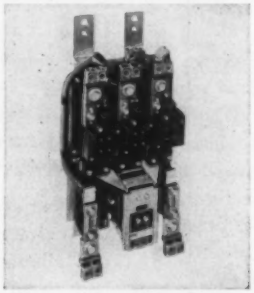
sizes for medium or light duty. Hinge is shown in closed position with pressure applied. **Simmons Fastener Corp.**, N. Broadway, Albany 1, N. Y. D

Circle 678 on Page 19

Vertical-Action Starter

requires only 270 sq in. space

Size 5 vertical-action starter is easily maintained and is designed for fast wiring. Coil, contacts, and overload relays can be changed without disturbing external connections. Up to four extra interlocks can be added, in addition to the holding circuit interlock. Unit requires 270 sq in. space. Pushbutton and selector-switch kits are available for ad-



dition to the starter in general-purpose enclosure. **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis. K

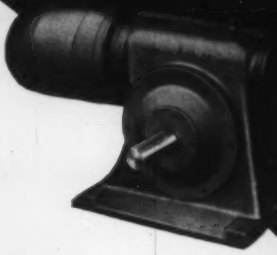
Circle 679 on Page 19

Pump

has three discharges

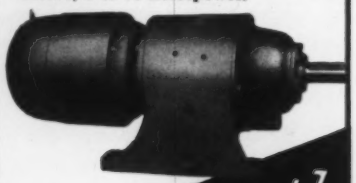
Model 5S-4520 outside flange-mounted pump has three discharges, one on the right side, one on the left of the housing, and one,

D.O.James GEARMOTORS



RIGHT ANGLE GEARMOTOR—Horizontal or Vertical Drive, 8 sizes, ratio 6:1 to 100:1, ⅓ to 30 horsepower.

IN-LINE GEARMOTOR—Horizontal or Vertical Drive, 37 sizes, ratio 9.2:1 to 1200:1, 1 to 75 horsepower.



OUR 70th YEAR

THE D.O.James Gearmotors are of the same construction and high quality as the individual Gear Speed Reducers which we have been producing for so many years.

They cover a very wide range of ratios, horsepowers, and are an ideal, compact, efficient unit for many power and space-saving installations. They are designed and built by an organization that has been engaged in the manufacture of Gears for 70 years and that has successfully pioneered the Gear Speed Reducer to its present-day high standards.

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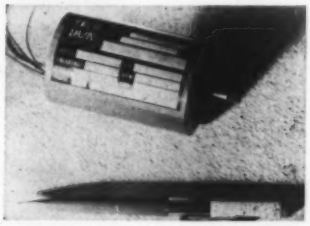
Circle 522 on Page 19

optionally tapped, through the inlet port of the mounting flange. Discharges can be used individually, in pairs, or simultaneously. Unit is available with either 1/10-hp, 3450 or 1725-rpm motor, or ¼-hp, 3450-rpm motor. It is equipped with self-adjusting pretested seal. Various diameter impellers are available for capacities to 30 gpm and heads to 27 ft. Pump is suitable where limited space is a factor and where a comparatively shallow reservoir is involved. **Ruthman Machinery Co.**, 1811 Reading Rd., Cincinnati 2, Ohio. G

Circle 680 on Page 19

Induction Motors

for continuous-duty applications



Series of 0.10-hp continuous-duty induction motors has applications such as drive motors for instruments, cameras, fans, pumps, or for any continuous-duty applications requiring an induction motor. Units operate at 400 cycle, 200 v ac, four pole, three phase, continuous duty, 11,500 rpm. Motors meet all applicable military specifications. **Task Corp.**, 1009 E. Vermont Ave., Anaheim, Calif. L

Circle 681 on Page 19

Potentiometer

has total resistance from 350 to 450,000 ohms

Model 7603 ten-turn precision potentiometer for servo mounting has

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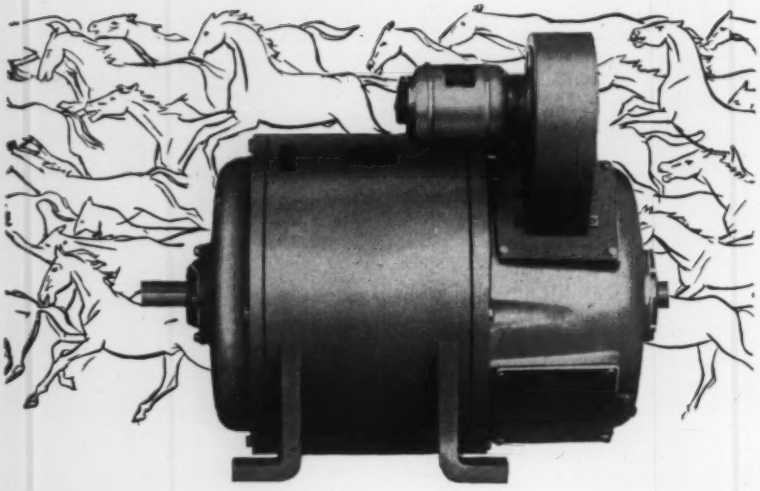
Circle 523 on Page 19

SPECIAL



five equals fifty

This DC motor is actually ten times the motor it appears to be. It is the size of a 5-h.p. motor, but it's rated 50 h.p. short-duty, and over 20 h.p. continuous.

In designing this particular shunt-wound motor, high power in a small space was the major consideration, but not the only one. It also had to accelerate to 6000 r.p.m. within one second and withstand frequent, fast reversals without excessive overheating. Physically, this small-scale giant measures just 16" long by 9½" dia., and weighs only 115 lbs.

Admittedly, this is a special motor. It is also typical of ESCO's unusual ability to design and build all kinds of special rotary equipment to meet particular needs. For over forty years ESCO has been pleasing its customers by finding answers that exactly match special requirements. Perhaps our solution to your particular motor problem will please you, too.

Refer to Esco Catalog in section 4a/E1 in Sweet's Product Design File, or write direct for general catalog No. 56PD. Why not also send us details on your special problem — we'll be glad to show you how we would go about solving it for you.

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

Circle 524 on Page 19

exceptional stability, standard independent linearity of ± 0.15 per cent, and minimum noise characteristics. Total resistance ranges from 350 to 450,000 ohms. Ambient temperature range is from − 55 to 80 C, with power rating of 5 w at 40 C. Full use of potentiometer resistance range is possible, since 90-deg overtravel is available at

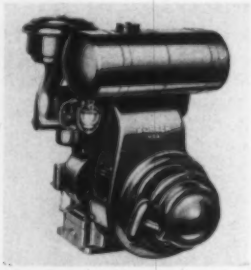
each end of the coil. One-piece molded housing is highly resistant to moisture. Design of rotor and slider provides essentially zero backlash and low torque. **Helipot Corp., Div., Beckman Instruments Inc.**, Newport Beach, Calif. L

Circle 682 on Page 19

Air-Cooled Engine

has self-contained starter

K160T air-cooled engine is a 6.6 hp, four-cycle, short-stroke unit with retractable starter. Easy starting is provided by a self-contained starting unit attached to the engine, eliminating the need for a rope. Rotating screen is positioned under starter housing, and insures circulation of clean, cool-



ing air over engine cylinder. Unit is well adapted for use on concrete mixers, lift trucks, weed cutters, power sweepers, rollers, snow removal equipment, pumps, tractors, sprayers, and augers. **Kohler Co.**, Kohler, Wis. K

Circle 683 on Page 19

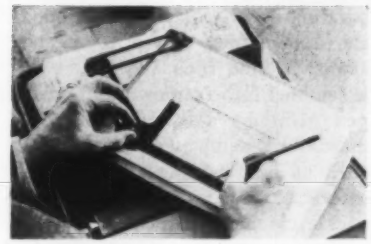
ENGINEERING DEPARTMENT

EQUIPMENT

Portable Drafting Machine

in three drawing board sizes

Draftette portable drafting machine is attached to a portable drawing board that fits easily into a briefcase. Unit takes the place of



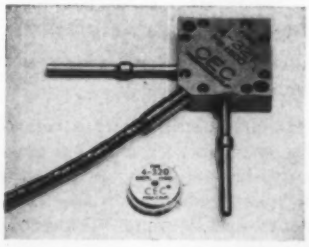
T-square, ruler, protractor, and triangles. Instrument is all aluminum, anodized jet black, with white-filled numbers and letters of the scale, and 180-deg protractor. It is available with 10 x 13, 11 x 17, or 20 x 26-in. drawing board. **David Miller & Associates,** Box 572, Beverly Hills, Calif. L

Circle 684 on Page 19

Miniature Pressure Pickups

withstand 200-g acceleration

Type 4-320 miniature pressure pickup is ½ in. in diam and less than ¼ in. thick. Small size, light weight, and ability to withstand 200-g acceleration without damage permit use in airborne applications. Differential and gage pressure ranges, from ±7.5 to 50 psid and 25 or 50 psig, are available for operation at line pressures to 300 psi. Type 4-321 unit provides Type



Circle 525 on Page 19→

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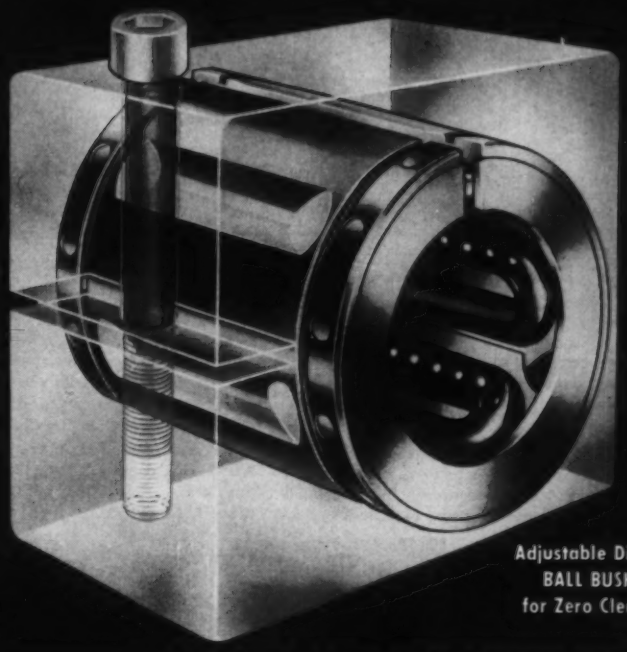
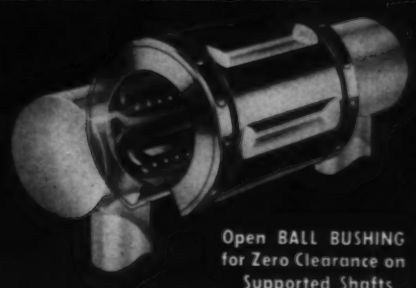


Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**

Precision Series "A" and Low Cost Series "B" BALL BUSHING



Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
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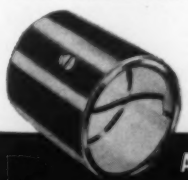
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of ¼" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.



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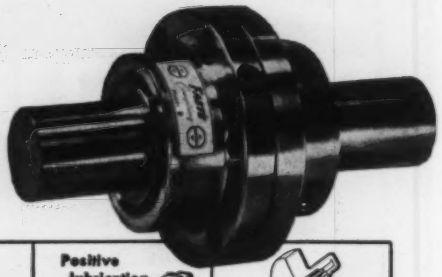
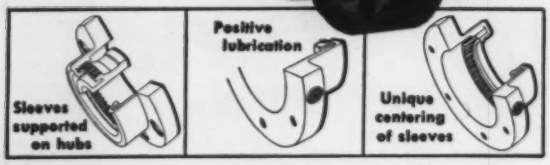
FAST'S Model B Coupling





reduces downtime and upkeep for light-to-medium drives!

Now you can profit from the durability and economy of famous Fast's couplings in a smaller and lower-cost version—available in 5 sizes for shafts ½" to 3⅛" in diameter.

The Model B coupling gives you the same features that have made Fast's the world's leading coupling for over 35 years. You get the same trouble-free performance, longer service life and lower maintenance costs. You also get prompt delivery because stocks are on hand to meet practically every need. Free engineering service is also available.

Write today for more details to KOPPERS COMPANY, INC., Fast's Coupling Dept., 3502 Scott Street, Baltimore 3, Maryland.

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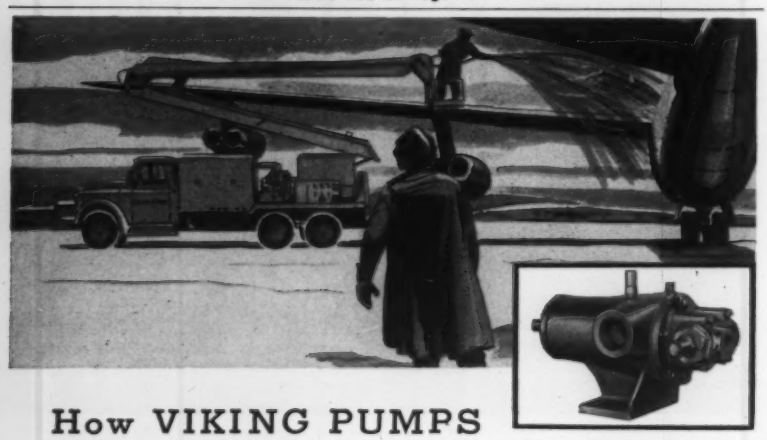
KOPPERS

THE ORIGINAL *FAST'S Couplings*

Circle 526 on Page 19



Model HL-195 Viking Pump Operates at 1800 RPM

How VIKING PUMPS help de-ice planes

Units built by Pitman Manufacturing Company, Kansas City, Missouri, are helping the U. S. Air Force answer the problem of de-icing, defrosting and de-contaminating parked aircraft. An integral part of each unit is a Viking HL-195 Pump. Positive action of pump delivers fluids to 50-foot high platform, under pressure of 100 psi, for spraying planes.

If you have the problem of lifting liquids under pressure, better investigate Viking Pumps.

For information, see your nearby distributor or write for bulletin 58SH.

VIKING PUMP COMPANY

Cedar Falls, Iowa, U.S.A. In Canada, it's "ROTO-KING" pumps

See our catalog in Sweet's Product Design File

Circle 527 on Page 19

Engineering Equipment

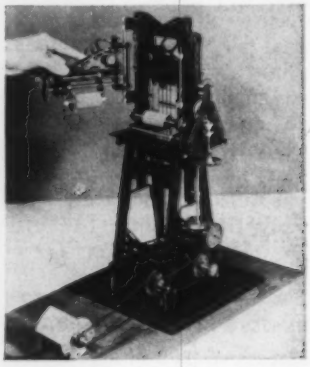
4-320 with a stainless-steel casing, 1 in. square and ⅜ in. thick. Designed chiefly for differential measurements, unit can also be used for gage pressures by venting the reference inlet to atmospheric pressure. **Transducer Div., Consolidated Electrodynamics Corp.,** 300 N. Sierra Madre Villa, Pasadena, Calif. L

Circle 685 on Page 19

Construction Kit

for making working models of machines and mechanisms

FAC construction kit permits the building of precision working models of machines, drives, or mechanisms. Round rods and beams are assembled into frameworks by rugged clamping means. Variety of mechanical components is provided, such as ball bearings, spur, bevel, internal, and worm gears, gear racks, ratchets, sprockets, pulleys,



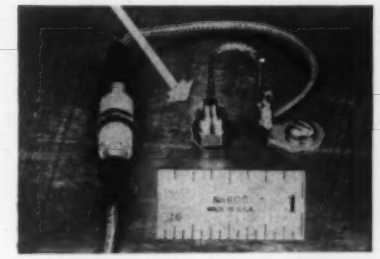
sheaves, couplings, springs, wheels, discs, and universal joints. Models can be used as machines and test equipment for research and development. Working model of a log saw is illustrated. Kit is available in two sizes, one with 2700 parts and the other with 4700. **FAC Division,** 9551 Grand River Ave., Detroit 4, Mich. H

Circle 686 on Page 19

Subminiature Accelerometers

have acceleration range from 1 to 40,000 g

Series 600 subminiature accelerometers, which weigh only 0.5 grams, are available for shock and vibration measurements of small components and systems. Transducers



employ barium titanate in compression for the sensing element, attaining natural frequency of 150 kc and sensitivity of 1 mv per g. Acceleration range from 1 to 40,000 g, and frequency coverage from 5 cps to 50 kc, provide wide operational characteristics. Units are equipped with 6-ft, subminiature, low-noise cable designed for extreme flexibility. **Columbia Research Laboratories,** MacDade Blvd. & Bullens Lane, Woodlyn, Pa. E

Circle 687 on Page 19

Ruled Vellum

has nonprintable grid lines

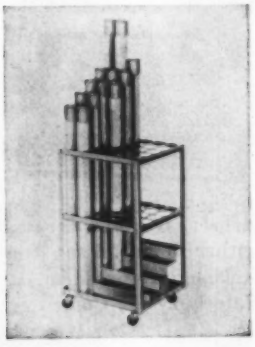
New Blutex vellum contains grid lines which disappear completely in printmaking. Surface takes dense, opaque pencil lines that resist smudging and smearing, and assure fast printback and sharp reproductions. Grid lines permit working to scale without the use of scaling instruments. **Frederick Post Co.,** 3650 N. Avondale Ave., Chicago 18, Ill. J

Circle 688 on Page 19

Blueprint File

is mobile, tubular unit

Plan-Mobile contains dual-tiered circular tube compartments which hold upright rolled blueprints,



THE ALL PLASTIC VALVE THAT

DEFIES CORROSION

VALCOR's all plastic, corrosion-resistant solenoid valve, SV-5100 series, is the only solenoid valve that has no metal contact with the fluid—ever. Specifically designed to handle most of the corrosive media so widely used in industry, VALCOR's new, all plastic solenoid valve will, in many cases, outlast stainless steel valves 100 to 1.

If you have a corrosive media problem, from sulphuric acid solutions to citrus juices, try this new VALCOR valve on your toughest application. Prove for yourself how this new valve defies corrosion. List prices start at $8.50.

IMPORTANT: Hundreds of other valve variations, in design and pressure ratings, are inherent in this new SV-5100 series. By incorporating some of the very newest engineering and chemical formulas, we can offer valve variations designed to meet almost any corrosion problem you might be faced with.

Write today for new catalog sheet. For specific information, please send us pertinent application details.

VALCOR ENGINEERING CORP.
5365 CARNEGIE AVENUE, KENILWORTH, NEW JERSEY

VALCOR
SOLENOID VALVES

Circle 528 on Page 19

CHACE
THERMOSTATIC BIMETAL
Actuates Another Precision Product...

A Product of General Electric Company Plainville, Connecticut

TYPE TQL CIRCUIT BREAKERS

The "Fill 'er up!" order at gas stations is carried out with maximum protection against short circuits or overloads in the dispensing pump circuit, thanks to General Electric Company's widely-used Type TQL switching neutral, common-trip circuit breaker. This device is designed to disconnect ALL conductors of the circuit from the source of supply, thus meeting NEC (National Electrical Code) requirements.

In addition, the Type TQL breaker is available in single-, 2- and 3-pole models with plug-in features which enable it to be plugged easily into the stab and bus-bar assemblies of load center and panelboard interiors. This is accomplished by means of self-aligning silver-plated copper pressure contacts. Contact pressure is maintained by spring-steel clips.

The Type TQL circuit breaker is one of the G-E series of molded case circuit breakers which employ thermostatic bimetal elements manufactured and assembled entirely by Chace. To insure maximum circuit protection and instantaneous trip-action all Chace bimetal elements are precision-rolled to the closest tolerances, specially processed to prevent metal separation, "torture-tested" under gruelling conditions, and rigidly inspected. This 4-phase leadership program—adhered to for over a third of a century of exclusive bimetal specialization—explains why more quality-conscious manufacturers look to *quality-famous* Chace in more bimetal applications than any other company in the field.

Remember *Chace* when you design for circuit protection or temperature actuation and indication. Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specifications. (We do not manufacture complete controls or any other devices in competition with our customers). Write today for our new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal"—it's full of interesting applications, engineering data, and helpful ideas for your designers.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Engineering Equipment

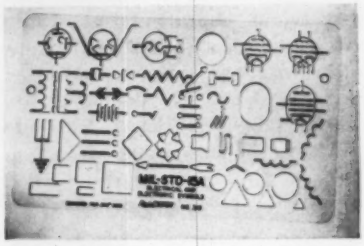
charts, plans, drawings, maps, and tracings. Each opening is 2½ in. in diameter. Unit moves easily and quietly on ball-bearing casters. It is available in 30 and 60-file capacity sizes. **Stacor Equipment Co.**, 295 Emmet St., Newark, N. J. D

Circle 689 on Page 19

Drafting Template

for electrical and electronic symbols

No. 315 Mil-Std-15A electrical and electronic symbols template is predicated on 0.250-in. grid. Made



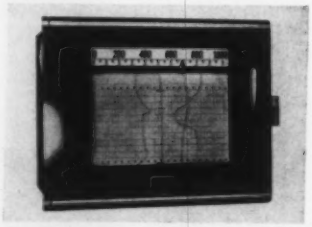
of 0.040-in. mathematical quality plastic, template is precision milled with bevel cut. Overall size is 8¾ x 5 in. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif. L

Circle 690 on Page 19

Telemeter Receiver

prints up to 16 separate records

Multiple-printing strip-chart Metameter telemeter receiver prints out up to 16 separate records from as many telemetering transmission centers. Using a multiple-switching arrangement, receiver monitors values from any distance. Variables need not be all of one kind. Instrument prints on a 12¼ in.



wide-strip chart, and is available with either 5 or 15-sec time-impulse telemetering system. **Bristol Co.**, Waterbury 20, Conn. B

Circle 691 on Page 19

THE ENGINEER'S

Library

Recent Books

Human Understanding in Industry. *By W. C. Menninger and H. Levinson; 104 pages, 5½ by 8 in., paperbound; published by and available from Science Research Associates, 57 West Grand Ave., Chicago 10, Ill.; $2.25 per copy.*

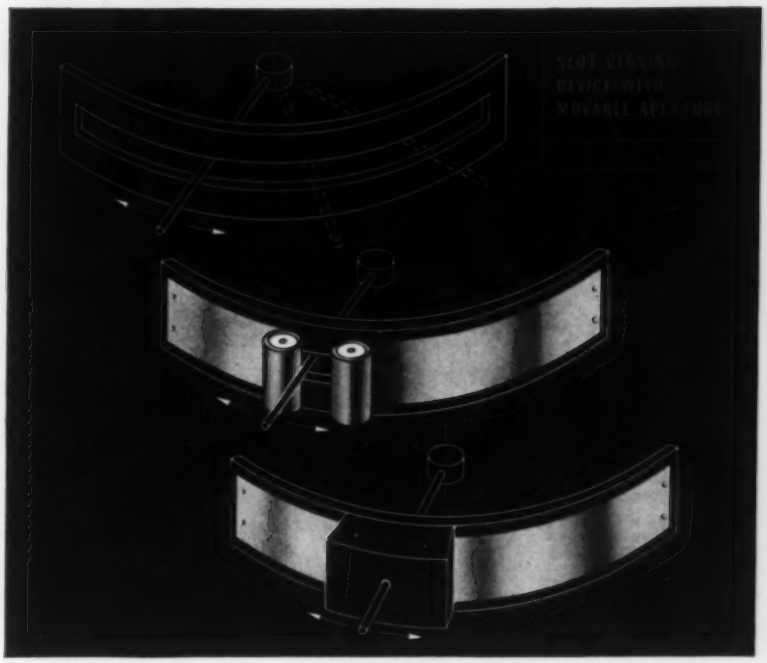
Organization of this material makes it suitable for use by individuals who serve in a supervisory capacity, or for use in a training program for supervisors. This illustrated book presents techniques for gaining co-operation of the various personality types found together in every project group. The specific purpose of the book is to serve as an aid to those interested in utilizing available manpower to the fullest extent.

Human Relations in Industrial Research Management. *Edited by R. T. Livingston and S. H. Milberg; 418 pages, 5½ by 8½ in., clothbound; published by Columbia University Press, 2960 Broadway, New York 27, N. Y.; available from* MACHINE DESIGN, *$8.50 postpaid.*

Based on the proceedings of the Sixth and Seventh Annual Industrial Research Conferences, this volume brings together 27 papers on the human aspects of organized research. Papers analyze the nature of research management jobs, role of the manager, and individual factors that affect processes of organization and management in industrial research.

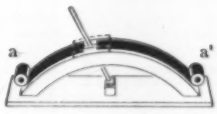
Basic concepts of a job are explored in an attempt to evaluate jobs of research organizations. Elemental systems of man and job in industrial research are examined and expectations of the organization described. Also considered are techniques used by research managers to improve human relations.

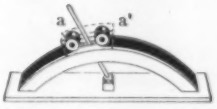
Engineered Work Measurement. *By D. W. Karger and F. H. Bayha, Magnavox Co.; 635 pages, 6 by 9 in., clothbound; published by Indus-*



Simplify Slot Closure

WITH NEG'ATOR® SPRINGS





TWO METHODS of mounting NEG'ATORS for slot closure. Above, the free ends of the balanced NEG'ATORS are attached to the traversing unit (the movable aperture) and the NEG'ATOR coils (a and a') are mounted, out of the way, on a stationary section of the equipment. Below, the free ends are fixed and the coils are mounted on the moving member. Where space is available, the mounting below is preferred because of minimized friction.

Paired, equal-force NEG'ATOR Springs, forming flat bands as they uncoil, make an effective cover for slots and provide a movable access through the slot as shown above. This is just another example of how alert engineers have utilized *constant-force* NEG'ATOR Springs to solve unusual design problems.

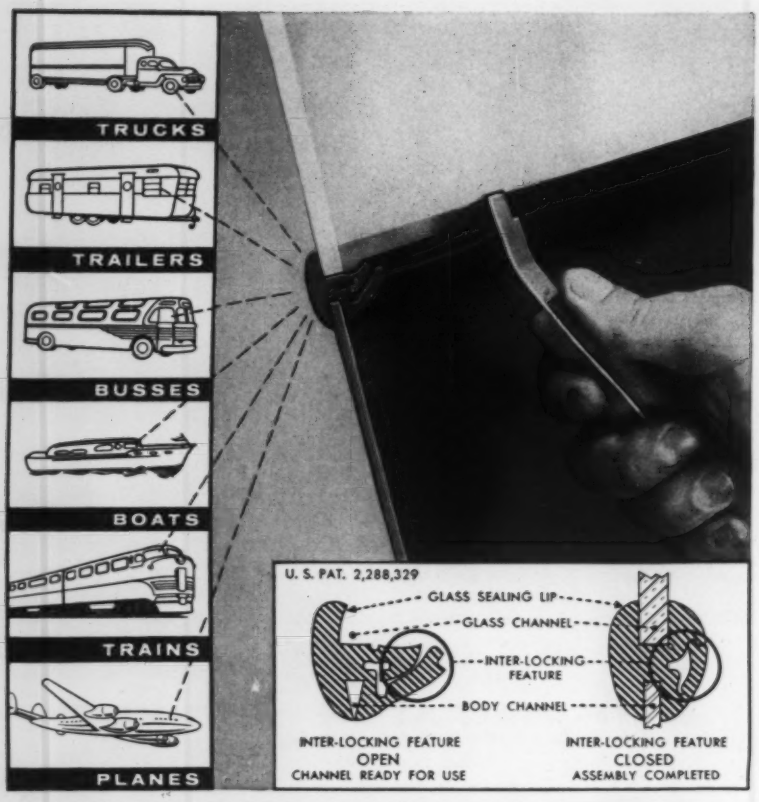
Slot closure devices incorporating NEG'ATOR Springs are inexpensive, compact and foolproof in operation. Each design utilizes two NEG'ATOR Springs to mask the openings created on either side of the movable aperture. One NEG'ATOR extends as the other re-coils and their equal and unchanging forces counterbalance each other.

Typical application possibilities for NEG'ATOR-equipped slot closure devices include: grinding machine shields, bomber gun turrets, machine tool ways, splash guards, dust enclosures, safety shields, electrical enclosures, and sound baffles—just to mention a few. Can NEG'ATOR Springs solve your particular design problem? Find out more about this versatile component—the first *constant-force* spring—by requesting Bulletin 310N.

HUNTER SPRING COMPANY

3 Spring Avenue, Lansdale, Pennsylvania

Manufacturers of: Precision Springs, NEG'ATOR® & FLEX'ATOR® Constant-Force Springs, Stampings & Assemblies, Retriever Reels, Force Gages, and Wire Fatigue Testers



Self-Locking Rubber Channel for Mounting Glass in Body Panels

Its *one-piece* design locks and seals in one operation. No extra locking-strip needed. It's the faster, simpler method for mounting glass in any type body panel—truck, trailer, bus, boat, train, plane, etc.

Extruded with inter-locking feature at direct right angle to body, the Continental Channel permits unhampered insertion of glass. Locking tongue is pressed into its matching groove which forces the lips against *both* the glass and body panel—a more positive seal with exceptional push-out pressure.

Compounded for maximum weather resistance and extra long life. Close durometer tolerances are held for uniformly tight seal against moisture and surest possible locking. These rubber channels can be positioned first on *either* glass or body panel. All details are shown in illustrated brochure gladly sent on request.

Ordered and re-ordered by the most prominent body builders, this Self-Locking Channel is another example of the creative thinking and ingenuity behind rubber parts by Continental. When you need rubber parts to do a specific job, call a rubber specialist *during the planning stage.* This often makes for economy as well as better end results. Call Continental —rubber specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

Library

trial Press, 93 Worth St., New York 13, N. Y.; available from MACHINE DESIGN, $12.00 *postpaid.*

This book provides an exposition of principles, data, and techniques of methods-time measurement, and co-ordinates this predetermined times system with well-established techniques of time and motion study. Each of the fundamentals of MTM is defined and illustrated, and special MTM mathematics, standards, and applications are included.

A special chapter on simplified MTM is intended for the design engineer to help determine which of several work methods is most efficient for performing a given operation.

Heat Transfer, Vol. 2. *By the late Max Jacob, Research Professor of Mechanical Engineering, Purdue University; 652 pages, 6 by 9 in., cloth-bound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, $15.00 *postpaid.*

This book deals with selected fields of heat-transfer applications related to thermometry, heat exchangers, regenerators, cooling towers, falling-liquid films, laminar and turbulent boundary layers, and liquid metals.

Analysis and discussion of heat radiation in spaces of simple configuration serve as an introduction to applications covered.

A special feature of this volume is the inclusion of a section containing revised supplements to some of the material in Volume 1.

New Standards

American Standard Definitions of Electrical Terms. *Each standard is 8½ by 11 in., paperbound, and side stapled; published by American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; available from either AIEE or American Standards Association Inc., 70 East 45th St., New York 17, N. Y.*

The following standards Groups are available:

C42.10—Rotating Machinery, 34 *pages;* $1.20 *per copy.*

C42.20—Switchgear. 38 *pages;* $1.20

per copy.

C42.30—Instruments, Meters and Meter Testing. 39 *pages;* $1.20 *per copy.*

C42.35—Generation, Transmission, and Distribution. 38 *pages;* $1.20 *per copy.*

The following standards Groups are available, prices upon request:

C42.25—Industrial Control Equipment.

C42.60—Electrochemistry and Electrometallurgy.

C42.70—Electron Devices.

C42.80 — Electrobiology including Electrotherapeutics.

C42.85—Mining.

When all Groups are completed, standards will cover the following fields in addition to those listed:

C42.05—General (Fundamental & Derived) Terms.

C42.15—Transformers, Regulators, Reactors, and Rectifiers.

C42.40, 41, 42, and 43—Transportation (General, Air, Land, Marine, respectively).

C42.45—Electromechanical Applications.

C42.50—Electric Welding and Cutting.

C42.55—Illuminating Engineering.

C42.65—Communication.

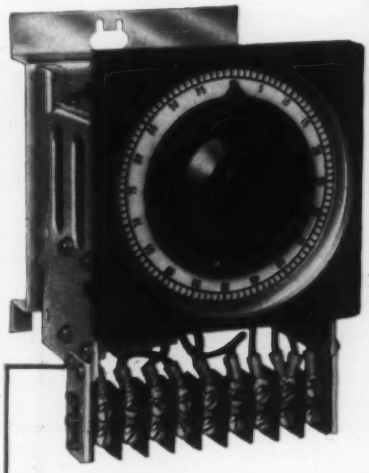
C42.75—Radiology.

C42.95—Miscellaneous.

Association Publications

Proceedings, Thirteenth Annual Meeting, Metal Powder Association, 1957; *published in two volumes, each 6 by 9 in., paperbound; available from the Metal Powder Association, 130 West 42nd St., New York 36, N. Y.*

Volume 1—General Session on Powder Metallurgy; 147 pages, $4.00 per copy. This volume contains papers which deal with the general aspects of powder metallurgy, i.e., sintering, characteristics of metal powders, design and use of sintered metal parts, equipment for compacting powders, developments in powder filters, and



Specifications

Dial — 1-99 Counts, adjustable

Speed — 400 counts per coil per minute maximum for intermittent use

Switch rating — 10 amps, 115 volts AC
Maximum Inrush
30 amps — Terminals 4-5
7-8
15 amps — Terminals 4-6
7-9

Coils — Continuous duty solenoids — Inrush current .9 amperes, 115 volt, 60 cycle

Life — Laboratory tests indicate an average of 5 million pulses on each count coil without maintenance

NEW! ... Eagle Signal announces development of special precision ADD-SUBTRACT COUNTER

A special new add-subtract counter has been announced by the Eagle Signal Corporation. (see complete specifications above) The basic function of the new device is to automatically control the number of units in a given area — thus simplifying inventory, stocking, and shipping problems.

Of extreme importance in materials handling operations, the new counter can be used in many and varied applications. For example, note Figure 1, a parking lot diagram, and Figure 2, a materials handling operation.

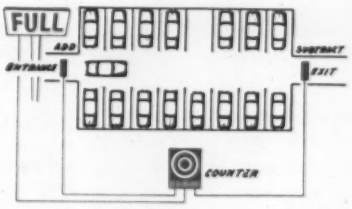


FIG. 1

In this parking lot, the counter is set for 16 vehicles, maximum. As the sixteenth vehicle enters, the counter relays an add pulse, and the "full" sign flashes on. When a car leaves, the counter will relay a subtract pulse, and the light will go out.

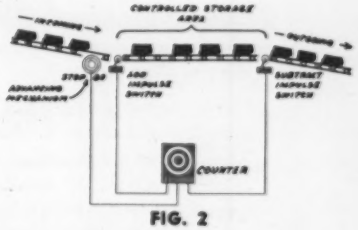


FIG. 2

In this application, a precise check is kept on inventory. No component enters or leaves the controlled storage area without registration by the add-subtract counter.

Where can you use the add-subtract counter? It will pay you to investigate this new product further, whether for built-in use in your product, or direct application. Eagle Signal engineers are ready with application assistance. Write now for more information, Bulletin 740, Eagle Signal Corporation, Dept. MD-258, Moline, Illinois.

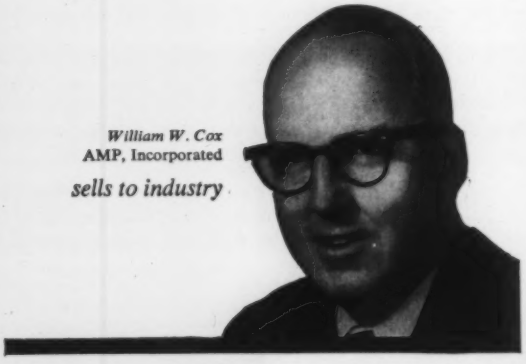
Can specialized business publication advertising actually sell?

By reputation, salesmen are reluctant to credit anything but their own selling efforts for getting names on the dotted line.

Actually, it's quite a different story. The most successful salesmen will tell you two important things about selling. 1. That the selling process is largely a matter of communicating ideas. 2. And that specialized business publication advertising can help importantly to register information with prospects.

Of course each salesman will express this in his own way ... but they all agree that selling would be far more difficult without the advertising that appears in the industrial, trade, and professional publications that serve the specialized markets to which they sell.

Here, for instance, is what a salesman has to say about this kind of advertising:



William W. Cox
AMP, Incorporated
sells to industry

Says Mr. Cox:

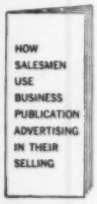
"The quickest way we can introduce a product is by introducing it through advertising in business papers. That way we get it around faster than we can by word of mouth alone. On occasion my home office has inquiries out to me before I can get to the customer or prospect to introduce a new product. They've already seen it in a trade magazine.

"It's interesting to note that within the last two weeks I received a survey which shows about 80% of the new customers we get on our books come through our trade publication advertising. Of course, our company is only 15 years old and we have grown from what you might say, *nothing*, to the biggest in our business. Certainly a lot of that has come from our advertising campaigns. Our name is known throughout the world right now, purely because of our advertising program. When I go to a prospect now, they know my company, they know my product... it makes my job easier, and opens doors when I have to make cold calls."

Ask your own salesmen what your company's business publication advertising does for them. If their answers are generally favorable you can be sure that your business publication advertising is really helping them sell. If too many answers are negative it could well pay you to review your advertising objectives—and to make sure the publications that carry your advertising are read by the men who must be sold.

How salesmen use their companies' advertising to get more business

Here's a useful and effective package of ideas for the sales manager, advertising manager or agency man who would like to get more horsepower out of his advertising. Send for a free copy of the pocket size booklet entitled, "How Salesmen Use Advertising in Their Selling," which reports the successful methods employed by eleven salesmen who tell how they get more value out of their companies' advertising.



You'll find represented many interesting variations in how they do this. Some are very ingenious; all are effective. You can be sure that more of your salesmen will use your advertising after they read how others get business through these simple methods.

The coupon is for your convenience in sending for your free copy. Then, if you decide you want to provide your salesmen with additional copies, they are available from NBP Headquarters in Washington, at twenty-five cents each. Or if you choose you can reprint the material yourself and distribute it as widely as you please. But first, send for your free copy.

NATIONAL BUSINESS PUBLICATIONS, INC.
Department 4D
1413 K Street, N. W.
Washington 5, D. C. STerling 3-7533

Please send me a free copy of the NBP booklet "How Salesmen Use Advertising in Their Selling."

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National Business Publications, Inc.

NBP

... each of which serves a specialized market in a specific industry, trade or profession.

metal powders in brazing and soldering.

Volume 2—Ferrites and Electronic Core Session; 57 pages, $3.00 per copy. Characteristics and applications of ferrites and ceramic permanent magnets are covered in this second part of the proceedings. Also included are papers which discuss magnetic core materials, magnetic cores in miniature electronic circuits, developments in magnetic storage and switching applications, and thermal expansion of ferrite materials near the Curie point.

Tentative Specifications for Copper and Copper-Alloy Arc-Welding Electrodes. *10 pages, 6 by 9 in., paperbound; published jointly by and available from either American Welding Society, 33 West 39th St., New York 18, N. Y., or American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; 40 cents per copy.*

Two types of stranded aluminum-bronze electrodes are covered by this specification. In addition, one type of electrode for use with the submerged-arc process is standardized.

Eight classifications include copper, copper-silicon, copper-tin, copper-nickel and copper-aluminum electrodes: Chemical composition, mechanical properties, and usability characteristics of each classification are given with tests for verifying each property.

An appendix is included to aid in selecting the best electrode for an application and provides information on filler metals for joining different base metals by different welding processes.

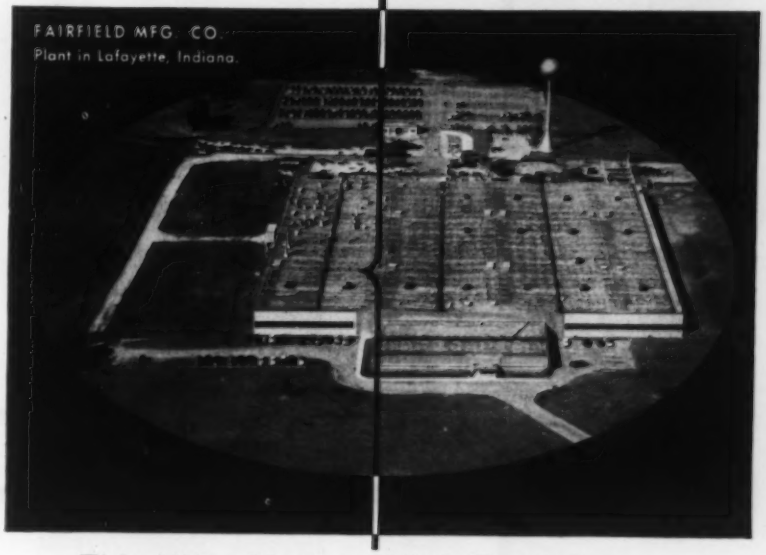
Government Publications

Wright Air Development Center Technical Reports. *Each publication is 8¼ by 10¾ in., paperbound, and stapled; copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

The following technical reports are available:

PB121802 (WADC TR 56-171). Layout of Workplaces. *By J. H.*

To ease your needs for . . . NEW CAPITAL EXPENDITURES



This Ultra-Modern, High Precision GEAR MAKING Facility..... AVAILABLE TO YOU

Simple arithmetic explains why, TODAY, many of America's leading manufacturers no longer undertake to solve the problems involved in making gears. For them, FAIRFIELD IS THE ANSWER!

Every facility is available at Fairfield — cost-cutting, ultra-modern equipment kept busy by volume production. This makes for economy and efficiency that can benefit YOU.

Check with Fairfield NOW on your gear production schedules. As one of the nation's largest independent producers, Fairfield can usually give you quickest service available and handle any production requirement. *Become a Fairfield customer; it pays!* CALL OR WRITE.

FAIRFIELD MANUFACTURING CO.
2307 S. Concord Rd. Lafayette, Indiana
TELEPHONE: 2-7353

Gears and Differentials for FINE GEARS Made to Order for:

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS

Circle 534 on Page 19

MECHANICAL ENGINEERS
ELECTRICAL ENGINEERS

Challenging job opportunity on the editorial staff of

MACHINE DESIGN

Here's your chance to break in on a growing field where aggressive creative work is really appreciated. MACHINE DESIGN has a staff opening for an engineer with an interest in both engineering and editorial work. This job provides stimulating contact with many engineering areas plus opportunity to grow and progress as a specialist in a particular branch of design engineering.

Some evidence of design engineering experience is necessary, and an ME or EE degree would be desirable. Writing ability and interest are also required, although a heavy background of editing or writing is not essential.

Salary will depend on experience; progress for the right man can be rapid. Headquarters are in Cleveland with opportunities for travel to attend engineering meetings and expositions.

If you are interested, send full details of your engineering background to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

Ely, R. M. Thomson, and J. Orlansky, all of Dunlap and Assoc. Inc.; 104 pages; $3.00 per copy. This report covers human engineering factors which affect performance of man-machine systems.

PB121895 (WACD TR 56-374). Mechancal Properties of Unalloyed Chromium. *By S. A Spachiner and W. Rostoker, Armour Research Foundation; 66 pages; $2.00 per copy.* Studies cover three commercial chromium alloys: MST-6Al4V, Ti-155A, and C-130AM.

PB131043 (WADC TR 56-567). Studies of Factors Affecting Thermal Stability of Titanium-Base Alloys. *By F. C. Holden, H. R. Ogden, and R. I. Jaffee, all of Battelle Memorial Institute; 56 pages; $1.75 per copy.* Mechanical performance of laboratory-grade material at 1300 F is discussed.

Dynamic Elastic Properties of Solids, PB 121701. *By T. R. Cuykendall and H. S. Sack; 109 pages, 8½ by 11 in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $3.00 per copy.*

This report summarizes the results of an investigation to determine the elastic modulus and internal friction of solids under alternating stresses. Measurements were made on nearly pure zinc, copper, and aluminum, and on plastics and elastomers over a wide range of temperatures. Specimens were subjected to flexural or torsional vibrations in the 1000-cps range.

An Investigation of the Fatigue Characteristics of Leaded Alloy Steels, PB 121834. *By G. W. Brock and G. M. Sinclair, University of Illinois; 53 pages, 8½ by 11 in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $1.50 per copy.*

This report contains results of an investigation to determine the effect of small amounts of lead on tensile and fatigue properties of SAE 1018, 1045, 8620, and 4340 steels. Mean fatigue limits and fatique life are included, and effect of notch sensitivity is discussed.

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Patents

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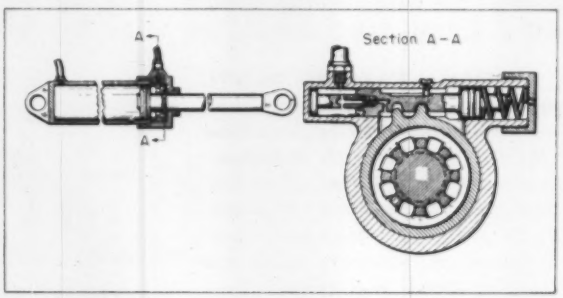

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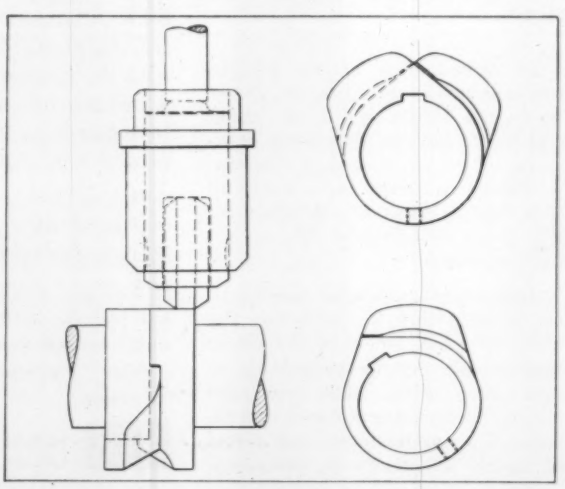
Selective engagement of a cam follower with either of two cams is carried out smoothly in a double-cam mechanism. Beveled slopes, which lead the follower from one cam surface to the other, overlap so as to insure a shallow rise with minimum thickness of the assembly. Application is in engine valve systems and



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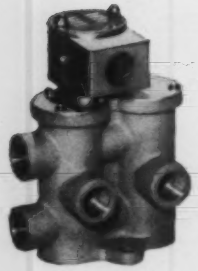

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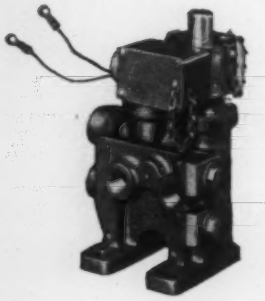

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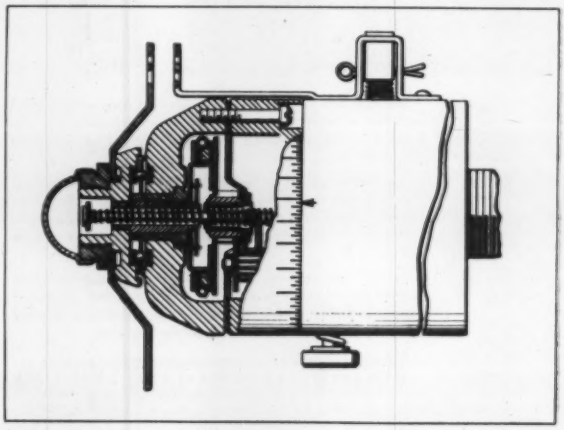
Noteworthy Patents

similar installations which must provide for camshaft rotation in either direction. *Patent* 2,817,248 *assigned to Maschinenfabrik Augsburg-Nurnberg A. G. (Germany) by Hans Motzet and Oswald Boller.*

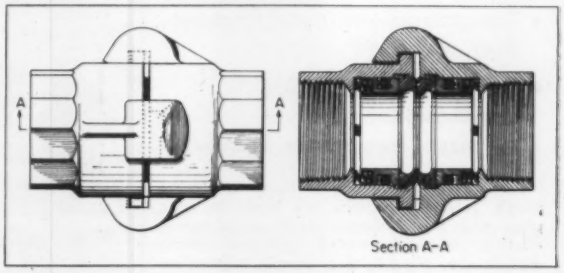
Constant-Speed Drive

Radial movement of centrifugal weights against an encircling garter spring provides variable-friction coupling of input and output members in an inex-



pensive constant-speed drive mechanism. At the overspeed condition, weights mounted on the output disc move away from the cup-shaped input member and break the frictional connection between input and output shafts. Opposite action occurs during an underspeed condition. In application shown here, constant-speed mechanism drives a wind-vane bomb-fuse timer. *Patent* 2,816,638 *assigned to General Time Corp. by Arthur B. Campbell.*

Quick-Disconnect Coupling



Sealing action which increases with fluid pressure is the characteristic of a two-part quick-disconnect coupling that employs axially floating packing rings. Initial sealing contact is provided by multiple compression springs which preload the packing rings to an extended position when coupling halves are separated. *Patent* 2,816,779 *assigned to Philadelphia Valve Co. by James A. Jenson.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

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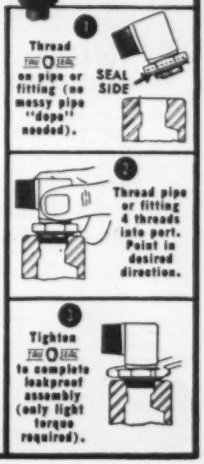
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Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
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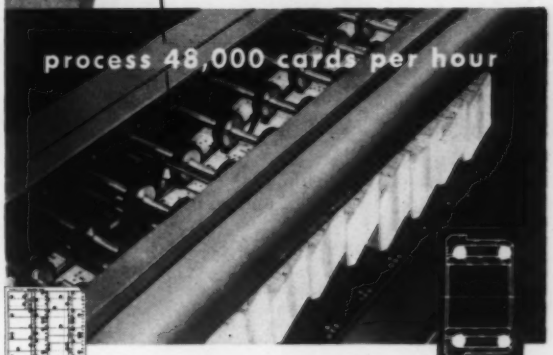
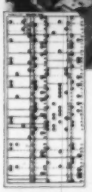
help the Remington Rand electronic sorter





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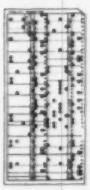
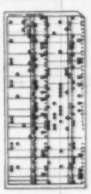


Versa-Twin is a double row ball bearing in which parts of the end product can form the inner and outer races. This unitized construction reduces the number of parts required, contributes to miniaturization, simplifies assembly, and assures maximum shaft alignment and stability.



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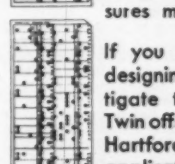

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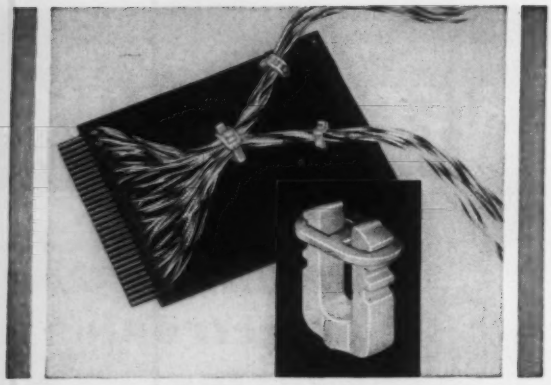

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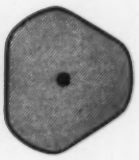

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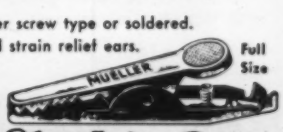

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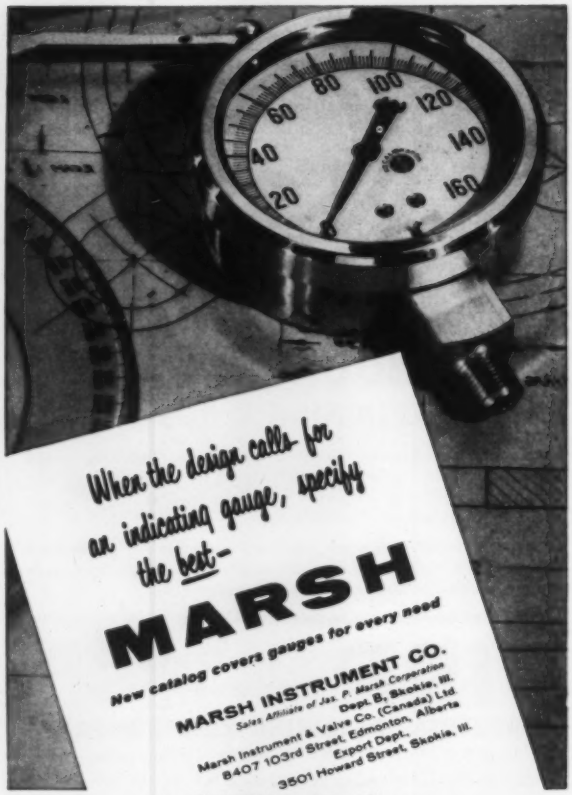
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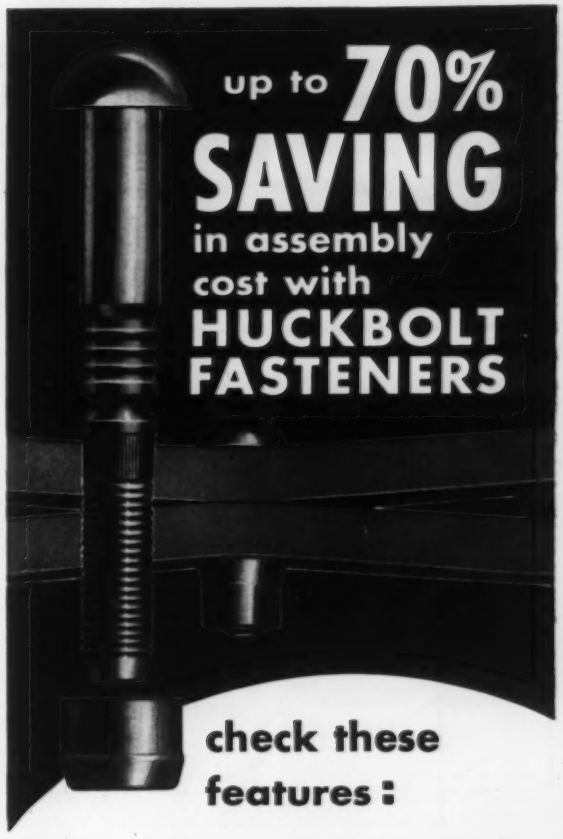

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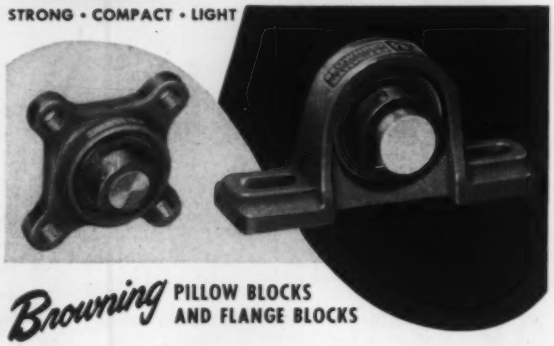

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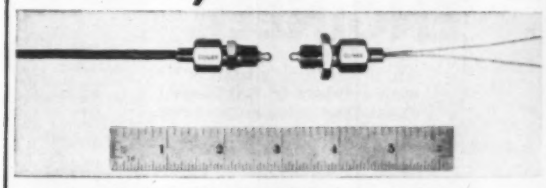

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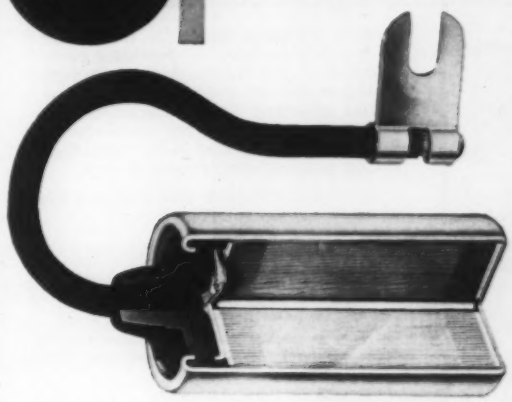

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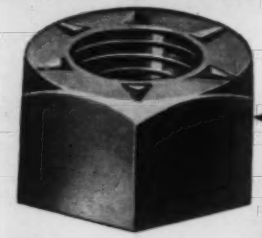

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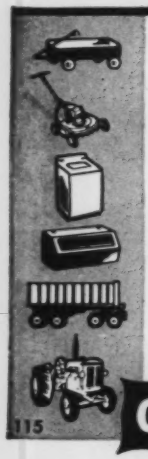

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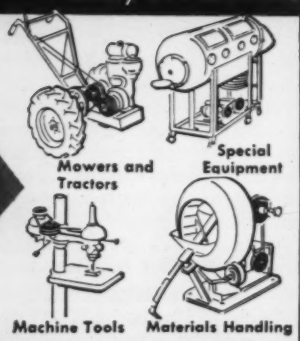

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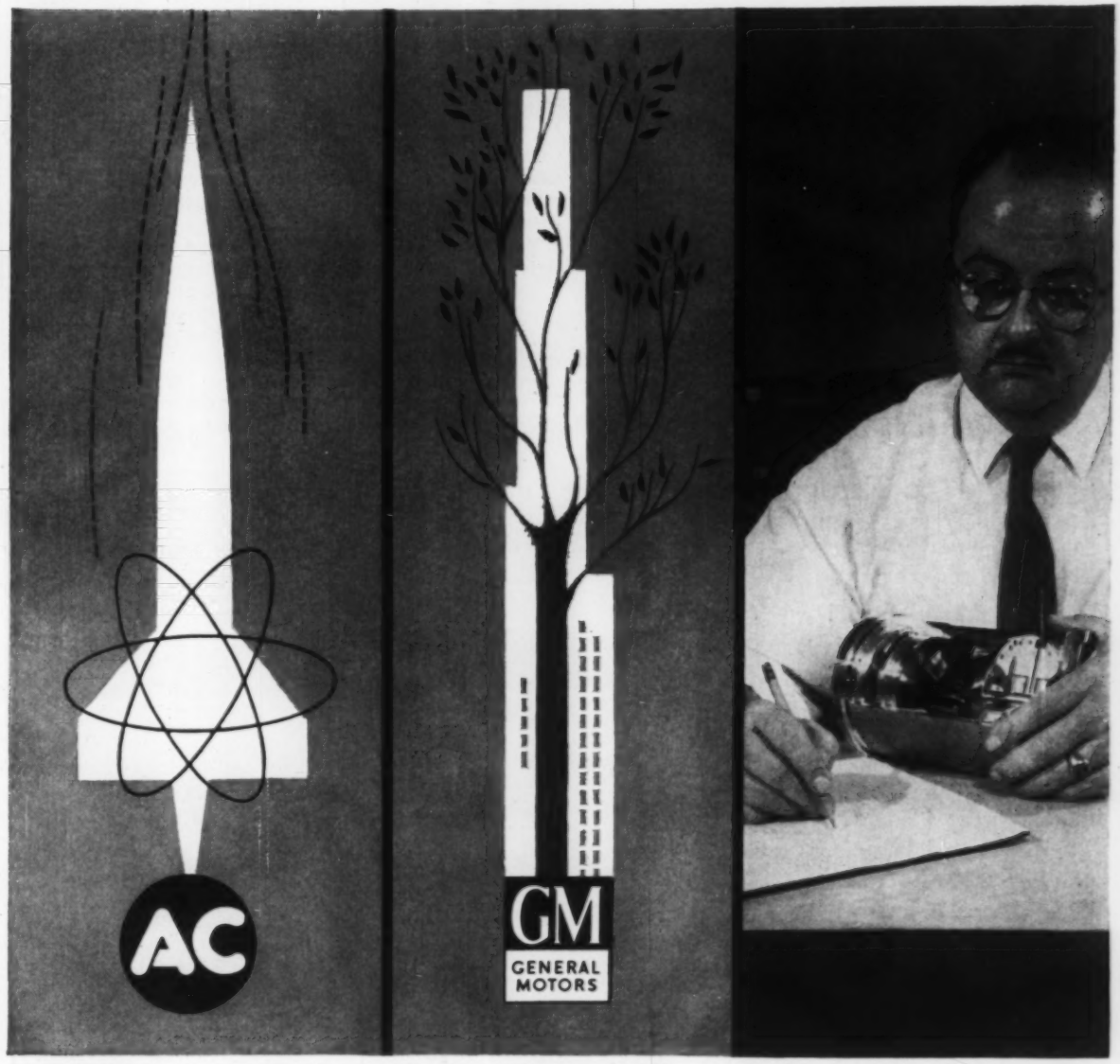

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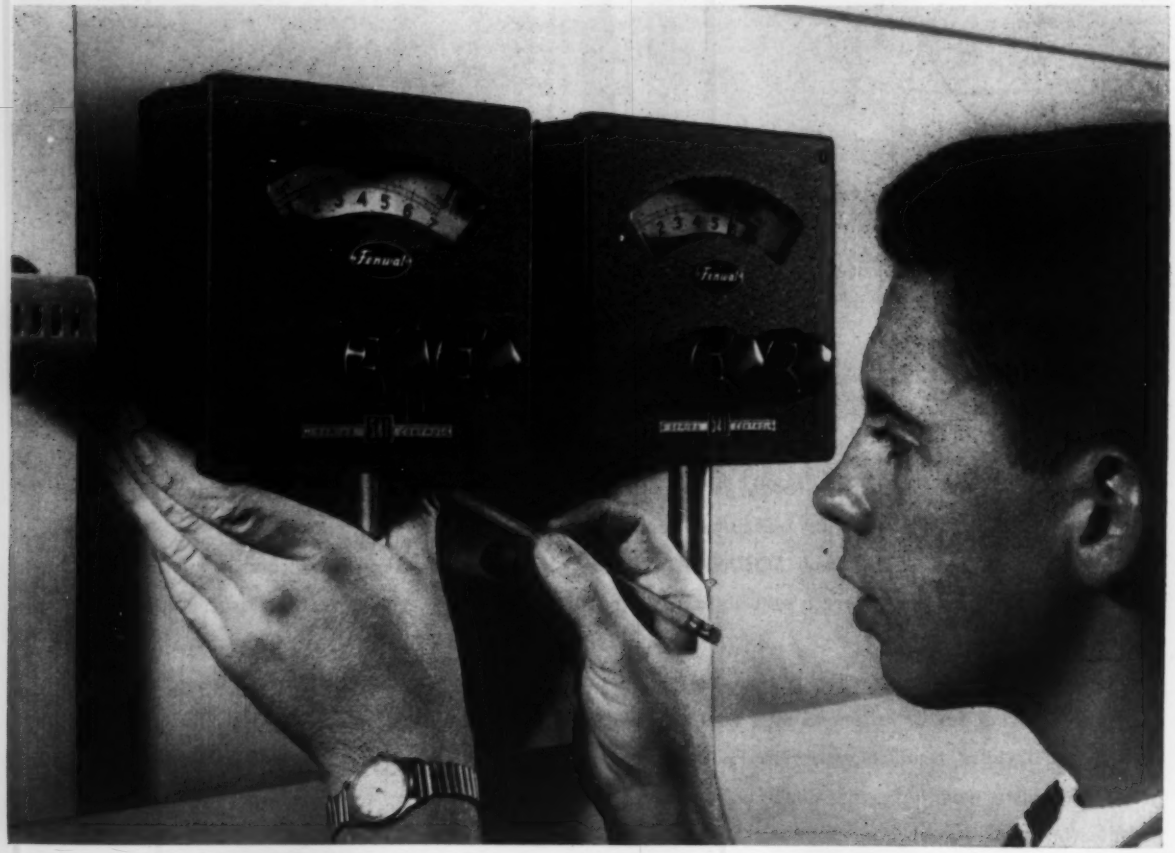

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

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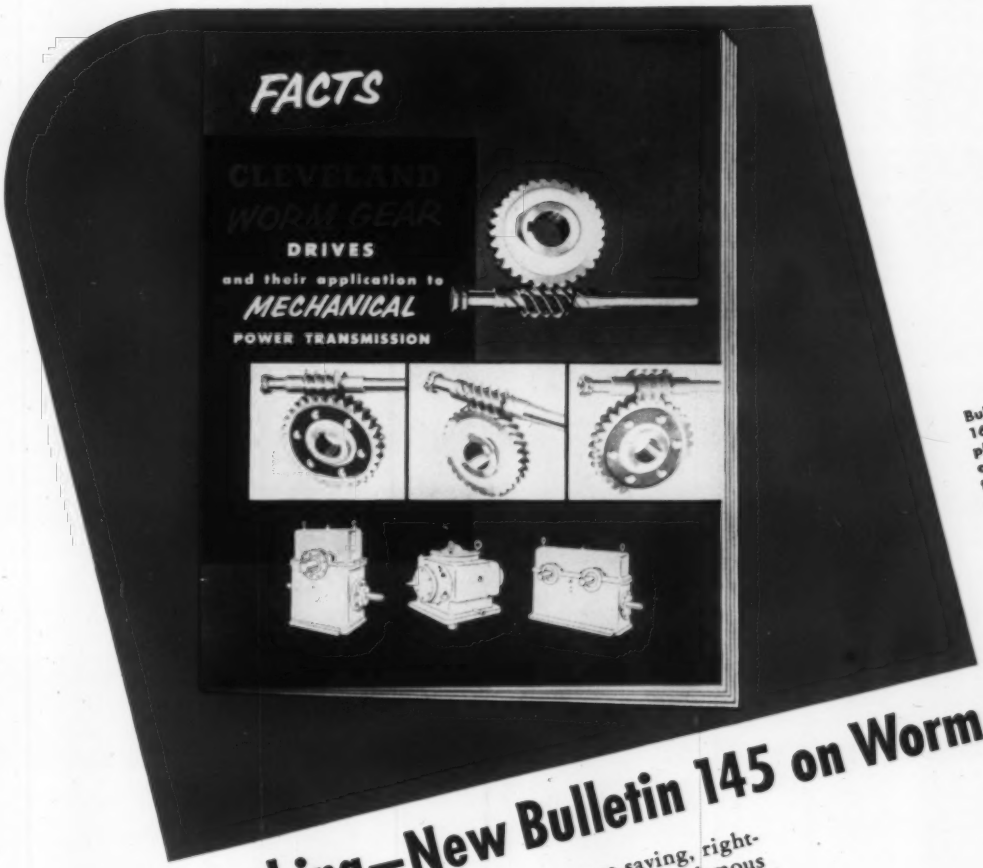

Bulletin 145 gives you 16 fact-filled pages of photographs and data on standard and custom-designed worm gear speed reducers and worm gearing components for built-in drives.

Yours for asking—New Bulletin 145 on Worm Gearing

WHENEVER you want a safe, space-saving, right-angle drive, you specify Cleveland. This famous worm-gear drive transmits power uniformly, smoothly, dependably, under even the most severe operating conditions, for a lifetime of trouble-free service. Clevelands actually improve with use. Thousands of units outlast their driven machines.

To know what Cleveland best meets any need—for speed reducer or worm-gear set—standard or special—write for new Bulletin 145. Just off press, it will bring your file up to date on this ever more popular drive. The Cleveland Worm & Gear Company, 3287 E. 80th St., Cleveland 4, O.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers, Limited.

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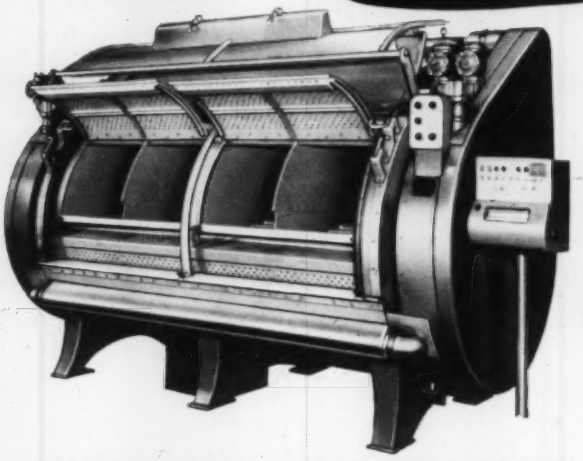
CUTLER-HAMMER

MOTOR CONTROL

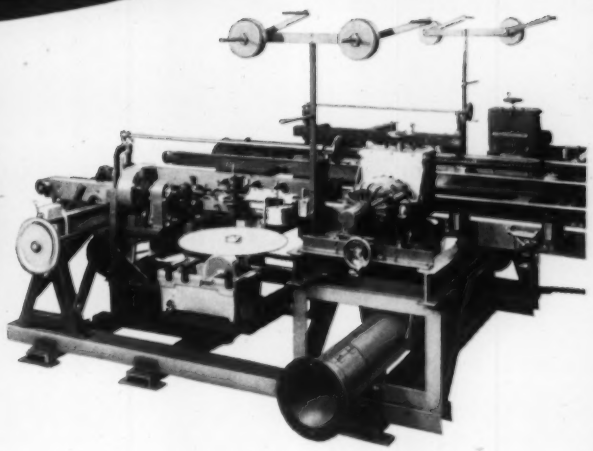
C-H

CHOICE OF THE LEADERS

THE MARK OF BETTER MACHINES

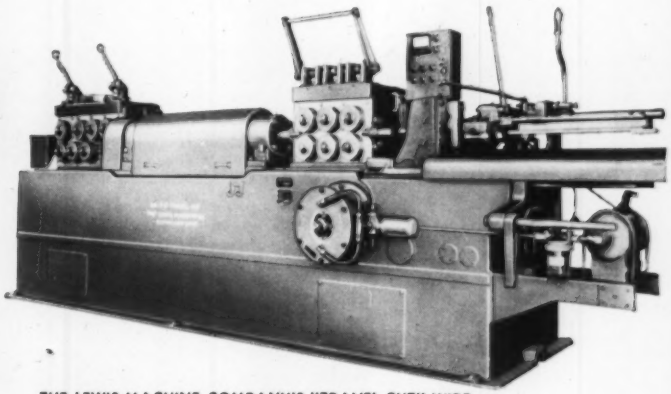


THE 1,500 LB. "MASTER" MANUFACTURED BY THE MILLER LAUNDRY MACHINERY COMPANY; DETROIT, MICHIGAN; INCLUDES CUTLER-HAMMER CONTROL AS STANDARD EQUIPMENT.



THE HIGH SPEED WALLBOARD SAW AND EDGE STRIPPER BUILT BY THE BRACKETT STRIPPING MACHINE CO. IS EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL.

BOTH THE WALKER-TURNER AND DELTA POWER TOOL DIVISIONS OF THE ROCKWELL MANUFACTURING COMPANY INCLUDE CUTLER-HAMMER CONTROL COMPONENTS AS STANDARD EQUIPMENT ON THEIR MACHINES.



THE LEWIS MACHINE COMPANY'S "TRAVEL-CUT" WIRE STRAIGHTENING AND CUTTING MACHINE USES CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND HEAVY DUTY OIL-TIGHT PUSHBUTTONS.

Preference For The Stars

Among the numerous manufacturers of every type of machine made there are always a certain few who are recognized as leaders. These leaders have won success because of the excellence of their product. Basic to such excellence is sound engineering, and sound engineering invariably means the utmost discrimination in the selection of components for inclusion on their machine. Able engineers respect able engineering. And for this reason Cutler-Hammer Three-Star Motor Control and Control Accessories are so frequently the repeated choice of the leaders, and the mark of better machines. CUTLER-HAMMER Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. Associate: Canadian Cutler-Hammer Ltd., Toronto.

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